New Scientist

WEEKLY 4 June 2022

THE FUTURE OF PSYCHEDELIC MEDICINE

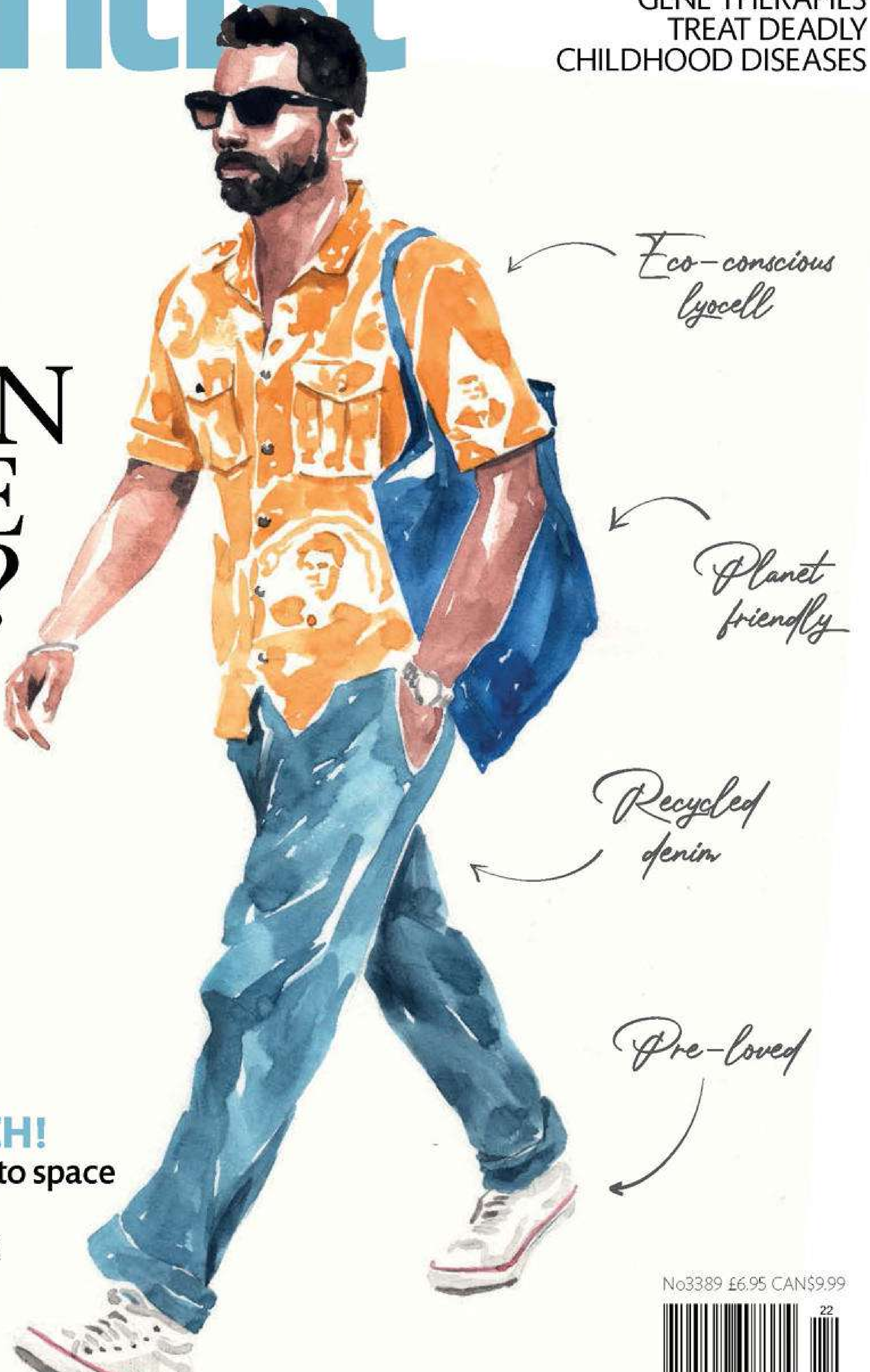
DNA SECRETS OF POMPEII REVEALED

HOW STARS STEAL PLANETS

GENE THERAPIES TREAT DEADLY CHILDHOOD DISEASES

CAN FASHION EVER BE GREEN?

The environmental cost of your clothing – and what you can do about it



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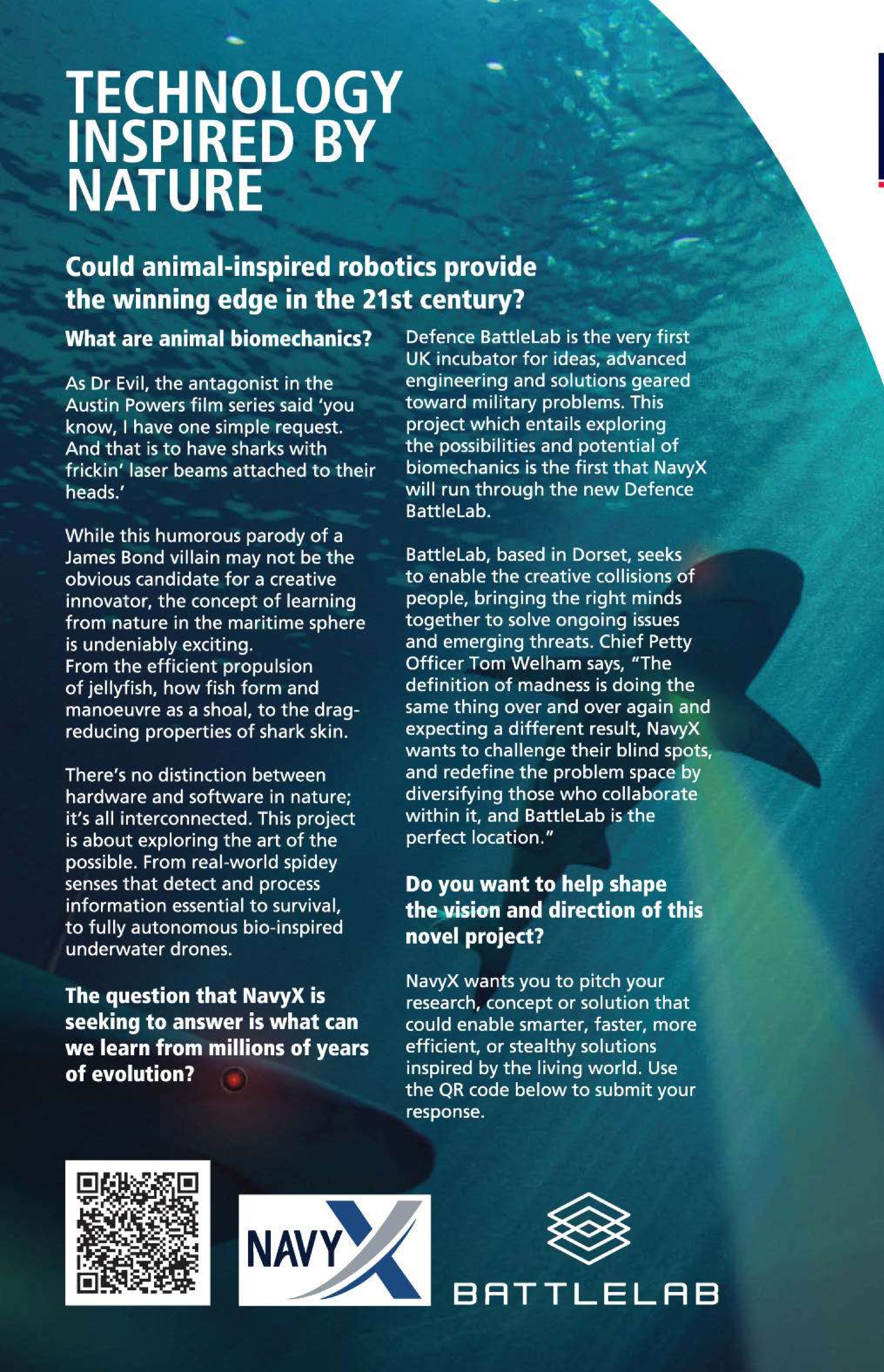

TECHNOLOGY INSPIRED BY NATURE

ROYAL NAVY

Could animal-inspired robotics provide the winning edge in the 21st century?

What are animal biomechanics?

As Dr Evil, the antagonist in the Austin Powers film series said 'you know, I have one simple request. And that is to have sharks with frickin' laser beams attached to their heads.'

While this humorous parody of a James Bond villain may not be the obvious candidate for a creative innovator, the concept of learning from nature in the maritime sphere is undeniably exciting.
From the efficient propulsion of jellyfish, how fish form and manoeuvre as a shoal, to the drag-reducing properties of shark skin.

There's no distinction between hardware and software in nature; it's all interconnected. This project is about exploring the art of the possible. From real-world spidey senses that detect and process information essential to survival, to fully autonomous bio-inspired underwater drones.

The question that NavyX is seeking to answer is what can we learn from millions of years of evolution?

Defence BattleLab is the very first UK incubator for ideas, advanced engineering and solutions geared toward military problems. This project which entails exploring the possibilities and potential of biomechanics is the first that NavyX will run through the new Defence BattleLab.

BattleLab, based in Dorset, seeks to enable the creative collisions of people, bringing the right minds together to solve ongoing issues and emerging threats. Chief Petty Officer Tom Welham says, "The definition of madness is doing the same thing over and over again and expecting a different result, NavyX wants to challenge their blind spots, and redefine the problem space by diversifying those who collaborate within it, and BattleLab is the perfect location."

Do you want to help shape the vision and direction of this novel project?

NavyX wants you to pitch your research, concept or solution that could enable smarter, faster, more efficient, or stealthy solutions inspired by the living world. Use the QR code below to submit your response.

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Instant expert: Meet your brain

Your brain is the most complex organ in your body. It produces your every thought, action, memory and experience of the world. Six expert speakers will teach you how our brains store memories and learn language, and why they need to sleep. Join us on 19 November at the British Library in London.

newscientist.com/events

Tour

Chile: The world capital of astronomy

With unique geography and climate, and 70 per cent of the world's telescopes, Chile truly is the world capital of astronomy. This tour will take you to world-leading observatories, including the Atacama Large Millimeter/submillimeter Array (ALMA) and the Paranal Observatory. Meet local experts and stargaze at sites near San Pedro, Santiago and Vicuña. From 27 March 2023 for 12 days. The cost is £7999.

newscientist.com/tours

Podcasts

Weekly

The team ask what DeepMind's new artificial intelligence, Gato, means for the future of machine consciousness. They discuss an archaeological detective story and how CRISPR gene editing has been used to make tomatoes rich in vitamin D. Also this week, the team examine the likelihood of monkeypox becoming the next global pandemic.

newscientist.com/nspod

SHUTTERSTOCK/FLUGLINSE

Look up Discover the wonders of astronomy in the Atacama desert

SARNER INTERNATIONAL COURTESY OF NATIONAL MUSEUMS LIVERPOOL

Sci-fi history Take time to look around this *Doctor Who* exhibition

Video

Science of *Doctor Who*

Doctor Who is the longest-running science fiction television series in the world. And while it might seem fantastical, many of the concepts that feature in the 59-year-old show are drawn from scientific ideas. We got a behind-the-scenes peek at the *Doctor Who Worlds of Wonder* exhibition at the World Museum in Liverpool, UK, and met K9, the Daleks and more.

youtube.com/newscientist

Newsletter

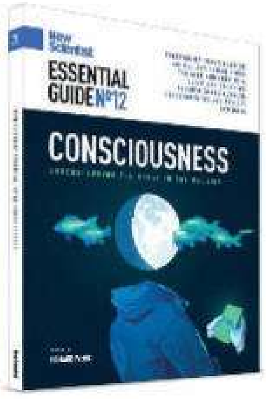
Fix the Planet

Reporter Adam Vaughan tells the story of a woman who blazed a trail for climate lawsuits. He interviews Marjan Minnesma, who, along with her Dutch group Urgenda, won a historic case against the government of the Netherlands in 2015, forcing it to upgrade its plans for cutting carbon emissions. Sign up for updates on all things climate.

newscientist.com/fix

Newsletter

> "You see in history very often that big disasters spark off big changes"



Essential guide

Consciousness is the ghost in our machine – our feeling of being and our relationship with the world. But what does it consist of and why do we have it? Delve into the ultimate mystery of being with the latest *New Scientist Essential Guide*.

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AN IMPORTANT MESSAGE FROM PROFESSOR NICK LEMOINE CBE MD PHD FMEDSCI, CHAIR OF THE MEDICAL RESEARCH FOUNDATION

Gifts in Wills could be the key to protecting the future of human health

Our experience of COVID-19 shows how suddenly a global health challenge can appear. As someone interested in science, you will understand that while nobody can predict what we will face next, we can be certain that the future will bring many more threats to human health.

As Chair of the Medical Research Foundation – the charitable arm of the Medical Research Council – I have seen the incredible impact that individuals who remember the Foundation in their Wills can have on the future of our health and wellbeing here in the UK. These gifts fund research and researchers which can have far-reaching implications for human health.

With a gift in your Will you can play a key role in providing the science that will protect the health of future generations.

Right now, the Foundation is funding research to tackle antimicrobial resistance, and investing in researchers like Dr Myrsini Kaforou – who will make the fight against antimicrobial resistance her life's work.

Without support at the crucial early stages, researchers like Dr Kaforou can be forced to abandon their passion and leave science altogether, with an immeasurable loss to future human health. Gifts in Wills provide the long term funding and security that allows the Foundation to invest in projects like Dr Kaforou's and lay the foundations for quality research in years to come.

Your Will can fund the rational response to health challenges that medical science provides.

> **"As scientists, our duty is to secure the future of research for the generations that follow."**
>
> Professor Fiona Watt, Patron of the Medical Research Foundation and Director of the European Molecular Biology Organization.

While we don't know what the future holds for human health in the UK, we do know that research, and the brilliant scientists driving that research forward, are the key to meeting those challenges for years to come.

Changing medicine today.
Changing lives tomorrow.
medicalresearchfoundation.org.uk

"The funding I received through the Medical Research Foundation will be transformative for my research." Dr Myrsini Kaforou

But many of these scientists rely on the generosity and foresight of fellow members of the public – people like you, who understand the power of science and are willing to leave a gift to medical research in their Wills. At the Medical Research Foundation, over 90% of our voluntary income comes from individuals who choose to include a gift in their Will – they are crucial in the Foundation's ability to fund research that will enable the next generation of scientists to make real world discoveries in the future.

I firmly believe that a gift in your Will to the Medical Research Foundation is an excellent investment and will have a lasting impact on science and on the future of human health in the UK.

Please consider this very special gift today.

Professor Nick Lemoine CBE MD PhD FMedSci
Chair of the Medical Research Foundation

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Make do and mend

The fashion world must change its environmentally destructive ways

FOR an industry that supposedly thrives on creativity, fashion has been appallingly slow to innovate to reduce its distinctly uncool environmental footprint.

On all three fronts in the planetary crisis – climate change, nature loss and waste – manufacturers and retailers of textiles and clothing could, and must, do better. Their carbon emissions are enormous, thirst for raw materials unsustainable and waste management systems rubbish. As just one example, every year we send 350,000 tonnes of clothing to landfill in the UK.

There are growing pockets of green creativity in the industry, but for the most part high-street brands seem intent on doubling down on the "fast fashion" business model that has done so much to line theirs.

We as consumers must also shoulder a large portion of the blame, gladly stuffing our wardrobes with cheap, shoddy and unsustainably manufactured garments, destined to be worn a few times and then unceremoniously dumped. Most people on Earth participate in this grotesquely wasteful cycle, helping to make clothing one of the most environmentally destructive industries (see page 38).

> "Keeping a garment for an extra year can cut its environmental footprint by 30 per cent"

Unlike some other damaging consumer choices, such as buying animal products and flying, it isn't really possible to simply opt out of clothes shopping. But of course there are ways of consuming that are less harmful. Indeed, consumers have disproportionate leverage in this sector. If patterns of demand change, such as shifting to brands that run buy-back schemes for unwanted clothing, the industry will respond. More powerfully, we can simply choose to wear our clothes for longer. Keeping a garment for an extra year can cut its environmental footprint by 30 per cent.

That, of course, requires a shift in our mindsets. But such things can and do happen. A few years ago, plant-based diets were the choice of the unconventional few. Now they are commonplace.

We need the same revolution to happen when it comes to clothing choices. Here's to a make-do-and-mend mindset becoming mainstream – and even fashionable. ▮

PUBLISHING & COMMERCIAL

Commercial and events director Adrian Newton

Display advertising
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Sales director Justin Viljoen
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CONTACT US
newscientist.com/contact

General & media enquiries
UK **Tel**+44 (0)203 615 6500
Northcliffe House, 2 Derry Street, London, W8 5TT
Australia 58 Gipps Street, Collingwood, Victoria 3066
US PO Box 80247, Portland, OR 97280

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OREGON STATE UNIVERSITY/NUSCALE POWER

Concept image of a future small modular reactor

Energy

Nuclear waste in spotlight

Mini nuclear reactors may create more radioactive waste for a given amount of power than conventional reactors, reports **Adam Vaughan**

A MUCH-vaunted first wave of mini nuclear power stations may produce more radioactive waste than traditional large-scale reactors when generating the same amount of power.

Small modular reactors (SMRs) have been mooted by their developers and proponents as a cheaper and faster way to build new nuclear power capacity, with UK prime minister Boris Johnson claiming they could be generating electricity by 2030. The US government has provided financial support to the firm NuScale Power to develop its version of the technology.

But to date there has been little independent assessment of how the radioactive waste produced by SMRs would compare with that from their large-scale peers.

Lindsay Krall at Stanford University in California and her colleagues used data NuScale Power has shared publicly with US authorities, and extrapolated to model the waste from three different SMR technologies. They compared SMR technology with a conventional 1.1 gigawatt nuclear reactor, roughly a third of the capacity of a nuclear plant being built in south-west England.

They have found that SMRs could increase the volume of short-lived low and intermediate-level waste – the two lowest of three categories – by up to 35 times compared with a large conventional reactor, when looking at waste produced per unit of electricity generated. For the long-lived equivalent waste, SMRs would produce up to 30 times more and for spent nuclear fuel, up to five times more. The variation in these figures reflects expected variation in SMR designs in development.

> **"SMR performed worse on nearly all of our metrics compared to standard commercial reactors"**

"The information right now being put out by reactor developers can be seen as promotional," says Krall. "SMR performed worse on nearly all of our metrics compared to standard commercial reactors."

The study suggests that SMRs produce higher volumes and greater complexity of waste because they are naturally less efficient. Nuclear power generation involves a nuclear chain reaction, in which one nuclear reaction in the reactor core creates neutrons that then go on to cause an average of one or more subsequent nuclear reactions. However, according to Krall's team, SMRs leak more neutrons out of their core than a larger reactor, so they cannot maintain the self-sustaining reaction for as long (*PNAS*, DOI: 10.1073/pnas.2111833119).

Diane Hughes at NuScale Power says the study relies on outdated information and the waste per unit of energy for its SMR compares favourably with large reactors. "We don't agree with the conclusion that the NuScale design creates more used spent fuel per unit of energy compared to currently operating light water reactors," she says.

The UK government has provided funding for Rolls-Royce SMR to advance its own version of the technology. This design wasn't considered in the new study, but a company spokesperson said Rolls-Royce SMR would be submitting estimates on waste volumes as part of its years-long journey through the UK nuclear regulatory approval process, which started in April. The Rolls-Royce SMR design "includes some technical innovations that reduce waste arisings", said the spokesperson.

Very few countries have made progress on plans for long-term facilities to store their nuclear waste underground, with Finland and Sweden two of the exceptions. "We need to get more serious about practically managing [SMRs] nuclear waste," says Krall. ▮

Archaeology

First genome of Pompeii resident

Human remains from towns destroyed by the eruption of Mount Vesuvius reveal the genetics of ancient Romans and the resilience of bone proteins, reports **Colin Barras**

MOUNT Vesuvius in southern Italy erupted in AD 79 to devastating effect, destroying several Roman settlements, including Herculaneum to the west of the volcano and Pompeii to the south-east. Analysis of human remains found buried under the ash and pumice that blanketed these ancient towns is revealing new details about the people who died in the eruption.

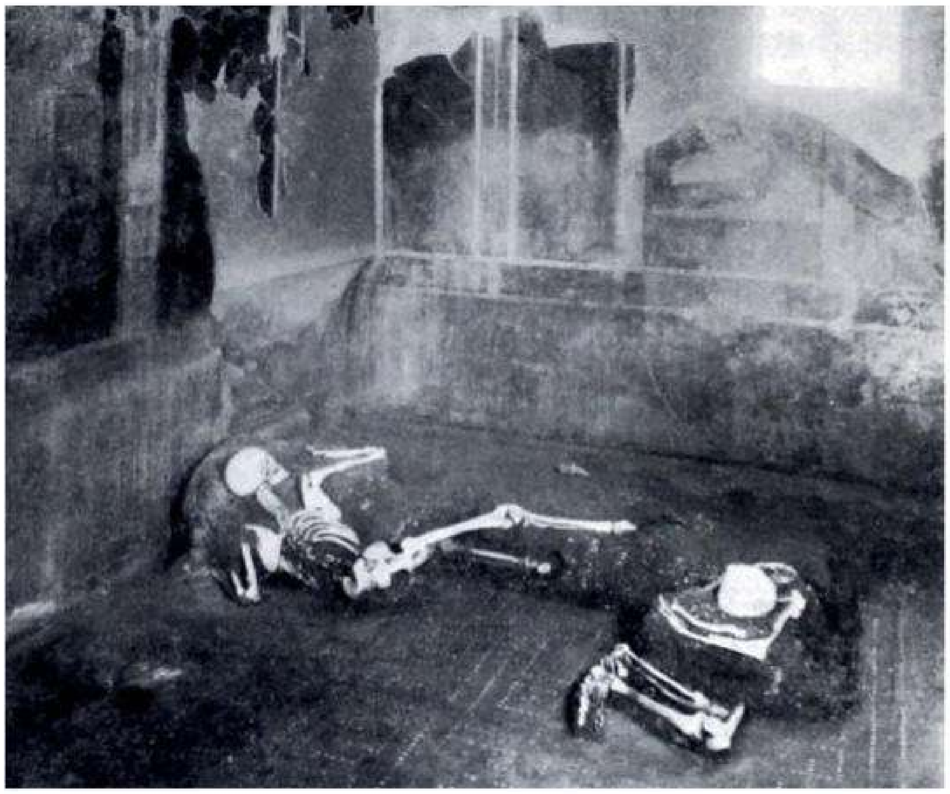
The eruption killed many of Pompeii's inhabitants, but it didn't destroy their DNA. The first complete genome from Pompeii has now been sequenced and it reveals genetic markers that haven't been seen before in ancient Roman DNA.

The volcanic ash and debris that covered Pompeii is estimated to have been at least 250°C – hot enough to kill people instantly and, presumably, cause significant damage to their internal tissues as well as their DNA.

"There was the expectation that the high temperatures would make our effort in DNA sequencing in Pompeii fruitless," says Gabriele Scorrano at the University of Copenhagen, Denmark. "Cremated bodies, for example, show no sign of DNA preservation, according to multiple studies."

But Scorrano and his colleagues decided to look for ancient DNA anyway. They focused on the skeletal remains of two people discovered in a building called the Casa del Fabbro, or House of the Craftsman. The pair – a man in his 30s and a woman who was at least 50 years old – seem to have been lying on a low couch in what may have been a dining room at the moment they died (pictured).

The researchers managed to obtain genetic material from both skeletons, although only the man's bones yielded enough DNA to piece together a full genome.



NOTIZIE DEGLI SCAVI DI ANTICHITÀ, 1934, P. 286, FIG. 10

The two individuals found in the Casa del Fabbro in Pompeii

Scorrano and his colleagues then compared the man's genome with those from 1030 ancient people who lived during the past 5000 years or so and 471 present-day people from western Eurasia. This revealed that the man who died in Pompeii had comparable DNA to that recovered from the skeletons of people living in Italy at the height of the Roman Empire.

However, the team did find differences. In particular, groups of genes on the man's Y chromosome and in his mitochondrial DNA were unlike those seen in earlier studies of ancient Romans. Instead, they were similar to sequences carried by some people living today on the Italian island of Sardinia.

Hints of bacterial DNA in the bone sample collected from the man in Pompeii are consistent with existing evidence from his skeleton that he had spinal tuberculosis (*Scientific Reports*, doi.org/hwkz).

"This pathology causes severe pain, such as lumbago and sciatica," says Scorrano. This might explain why he didn't flee when the eruption began, as many Pompeiians did.

It is only because of improvements in analytical techniques that we can now extract DNA from the skeletons preserved at Pompeii, says Pier Paolo Petrone at the University of Naples Federico II in Italy. He says the work shows there are "always new discoveries" to be made even at world-famous sites.

Petrone and his colleagues have also studied human bones recovered from Pompeii, as well as Herculaneum, where ash is thought to have been particularly hot. Estimates suggest it baked the town at temperatures of 500°C and killed some residents instantly, before vaporising their flesh.

He and his team extracted small samples of bone from seven human skeletons recovered from Pompeii and five recovered from Herculaneum. They found that they could isolate traces of ancient protein from all of the samples.

"This is the first work aimed at the detection of [proteins] in people exposed to high temperatures," says Petrone.

Surprisingly, he says, bones from Herculaneum contained a greater diversity of proteins than those from Pompeii, even though they experienced higher temperatures (*Scientific Reports*, doi.org/hwpv).

This may be because the bones at the two sites have encountered different environmental conditions since the disaster. The volcanic ash at Herculaneum is thought to have remained waterlogged for most of the past 2000 years, which might have limited the breakdown of proteins in the bones by microbes. Fluctuations in the local water table mean the ash at Pompeii periodically dried out, says Petrone, probably allowing for more microbial-driven decomposition.

The fact that the proteins in human bone can survive high temperatures could inspire further investigation, the team says. For instance, it may lead to research exploring which of the 1000 or so proteins generally found in human bone degrade at particular temperatures. Forensic investigators could use this to estimate a fire's temperature based on human remains. ■

250°C

Estimated temperature of volcanic ash that buried Pompeii

500°C

Estimated temperature of volcanic ash that buried Herculaneum

Space

Beware! Planet thieves are operating across the universe

Jonathan O'Callaghan

AROUND one in every 50 planets may have been stolen from other stars in their infancy – perhaps even in our own solar system.

We have thought for some time that worlds in very wide orbits around stars may have been born elsewhere, as it is hard for them to form so far from a star. The hypothesised Planet Nine in the outer reaches of our solar system, for example, may have been snatched from a passing star.

Such events may occur early in the lives of stars when they are born in dense clusters from the same cloud of dust and gas. These clusters can contain thousands of young suns, often packed relatively closely together before later spreading out. If any planets form around these stars, it might be possible for them to jump ship early on as other stars pass nearby.

Emma Daffern-Powell at the University of Sheffield, UK, and her colleagues worked out how often this might occur. They modelled an example cluster of 1000 stars, each separated by a third of a light year. Half of the stars had a single planet with an orbit at least as far out as that of Neptune – a simplistic model designed to represent how often planet transfer could take place in more complex environments.

The results showed that about 2 per cent of planets were "stolen" in the cluster's first 10 million years, meaning they were directly transferred between stars before they spread out. A further 2 per cent were "captured", meaning they became free-floating before being grabbed by another star. The rest stayed in their original system or were disturbed and ended up without a host star at all (*Monthly Notices of the Royal Astronomical Society*, doi.org/hwnb).

Artist's impression of an exoplanet orbiting a red dwarf star

DARRYL FONSEKA/ALAMY

Sean Raymond at the University of Bordeaux, France, says the study provides a novel look at the interactions of planets in young star clusters. "I didn't think there would be as many chances for stealing planets," he says.

For a star to grab a planet from another star, it would need to approach at a few hundred astronomical units (AU) – 1 AU is the Earth-sun distance. Captured planets would be in wider orbits than stolen planets because "the encounter is less energetic", says Richard Parker at the University of Sheffield, a co-author of the study. "If you have a very energetic interaction, that planet has to have a fairly small orbit," he says.

Both captured and stolen planets would also have less circular and more inclined orbits – ones that are angled to the flat plane of the system.

By directly imaging star systems, we can look for such planets by mapping their orbits. Matthew Kenworthy at Leiden University in the Netherlands says we have already seen evidence for such worlds. "My group has seen three planets where they're at 100 to 500 AU," he says.

At the moment we have only directly imaged a few dozen exoplanets, but that number should increase as more powerful telescopes like the European Extremely Large Telescope switch on in the coming years. ▮

Biotechnology

Self-replicating artificial cells move a step nearer

A SYNTHETIC cell membrane with machinery for cell division is a key step towards building an artificial cell with the ability to replicate itself.

Synthetic cell membranes now being created in the lab have many of the properties of real cell membranes, but they have lacked a "divisome", a group of proteins responsible for contorting the cell's membrane into hourglass-like shapes in preparation for division.

Now, César Rodriguez-Emmenegger at the Leibniz Institute for Interactive Materials in Germany and his colleagues have incorporated a part of the divisome from the bacterium *E. coli* into a fully synthetic cell membrane, called a dendrimersome.

The researchers explored whether the addition would give their artificial membrane the ability to transform into the correct shapes for division. They analysed it using spectroscopy and fluorescence microscopy, and discovered patterns that resembled those found in nature during cell division, as well as some non-natural ones (*Advanced Materials*, doi.org/hwp2).

Eventually, Rodriguez-Emmenegger and his team hope to incorporate more parts from living cells into their synthetic membrane.

The ultimate goal is a self-dividing artificial cell with synthetic parts, which could have properties not seen in nature, such as stronger and more stable membranes.

"It's not the final breakthrough – synthetic cells that self-replicate – but it is getting very close"

Self-dividing artificial cells may also help to answer fundamental questions about the origins of life.

It is a significant result, says Kate Adamala at the University of Minnesota, and a large number of technical problems had to be solved to achieve it, such as modifying the synthetic membrane to work with the cell division machinery.

But the goal of making synthetic cells divide is still elusive, adds Adamala. "It's not the final breakthrough, it's not: 'Yay, [synthetic] cells are self-replicating!' But it is getting very close." ▮

Alex Wilkins

Technology

3D-printed tourniquets could help save lives

James Stout

TOURNIQUETS have long been used on battlefields, and are now employed by medics responding to everything from mass shooting incidents to natural disasters. Over time, their design has been honed to a nylon strap that doesn't stretch and a plastic windlass that allows a user to tighten the device to constrict blood flow in a limb and stop bleeding.

But getting hold of them can be difficult in conflict zones. Limited supply chains and blockades in places like Gaza, Myanmar and Ukraine make these devices expensive and often hard to buy.

GLIA

3D printing tourniquet designed by Canadian company Glia

Now, several organisations have created open-source tourniquet designs that can be made anywhere people have a 3D printer, internet access and a spool of PETG plastic.

The 3D-printed components include a buckle and windlass, the tightening device made up of a strong barrel and locking clip. These can then be sewn together with a nylon and Velcro strap.

The Glia Tourniquet by Canadian company Glia has been available since 2018. It was designed to be manufactured using solar-powered 3D printers in Gaza, where an ongoing blockade limits access to basic medical supplies.

Most tourniquets now sold are designed for adult soldiers. Glia's design is for a broader range of people, including children, and requires only about 60 grams of PETG plastic, at a cost of about $1 per tourniquet.

Others have now developed similar products in response to Russia's invasion of Ukraine. 3D Printing for Ukraine, a group of volunteers, published its design in March. It allows plastic parts to be printed anywhere in the world, then tested and shipped to Poland, Switzerland or western Ukraine to be assembled and sent to the front lines. Other tourniquets are being printed in Ukraine using machines and spools of printer plastic donated by Polish firm Sygnis.

In Myanmar, where more than a thousand civilians have been killed after a February 2021 military coup, groups are using 3D printers to produce everything from tourniquets to weapons. Supply chains were slow before the civil war, so farmers have been printing tools there for some time. Now those printers are churning out medical devices.

Accessibility of 3D printing makes it useful for production in war zones, but ensuring that products are robust is key. "It is really important to have a high standard of safety," says Carrie Wakem, Glia's executive director.

3D Printing for Ukraine tests each batch before sending it to the front lines, and reports of failures or suggestions for improvements are sent back to individual makers or the community as a whole.

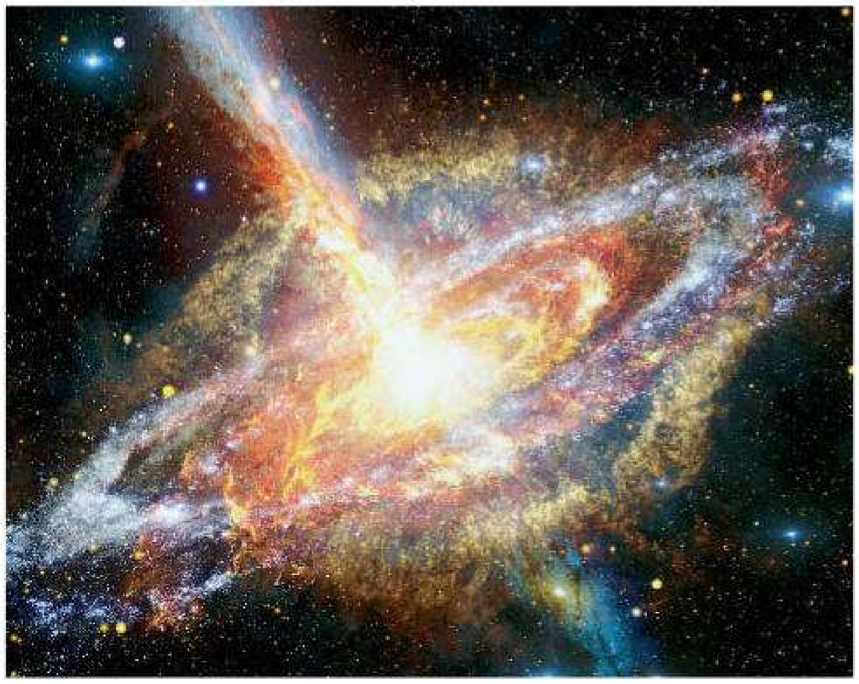
Wakem says Ukrainian medical authorities have got hundreds of printed tourniquets and are working on an open source quality-control test.

A former US Special Forces medical sergeant, who asked not to be named because he works in security in conflict zones, told *New Scientist* that, until there is rigid standardised testing, he can't recommend use of 3D-printed tourniquets. "But there definitely could be some promise," he says. ▮

Space

'Zombie' pulsar is active member of star graveyard

Jonathan O'Callaghan


SHUTTERSTOCK/NASA IMAGES

Artist's impression of a pulsar, a rotating neutron star

A PULSAR that is rotating just once every 76 seconds raises questions about how long these star remnants can remain active.

When a giant star explodes as a supernova, it can leave behind a dense core in the form of a neutron star. If this core is highly magnetised and spinning rapidly, it can send out regular pulses of radio emissions, and is known as a pulsar.

Manisha Caleb at the University of Manchester, UK, and her colleagues have discovered a particularly odd pulsar called PSR J0901-4046 using observations from the MeerKAT radio telescope in South Africa.

76

seconds, the time between flashes from a "zombie" pulsar

Located about 1000 light years from Earth, it rotates far slower than any known active pulsar, sending out a regular 300-millisecond-long pulse every 76 seconds (*Nature Astronomy*, DOI: 10.1038/s41550-022-01688-x).

"This is a very unusual type of radio-emitting neutron star," says Caleb. "It resides in what we call the 'neutron star graveyard' where we don't expect pulses to emit. It's like a zombie star."

Pulsars typically spin once every 0.25 to 2 seconds, but as they age, they lose energy and spin more slowly. Eventually, they stop sending out pulses and become regular neutron stars in a stellar graveyard. The boundary that this occurs at is known as the "death line".

The discovery more than doubles the previous record for the slowest-spinning pulsar, which took 23 seconds to rotate. So our understanding of where the death line begins "may need to be revisited", says Caleb. "Sources in the neutron star graveyard can still emit."

The fact that the star is still a pulsar challenges some theoretical models, says Cole Miller at the University of Maryland, College Park. ▮

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Field notes Spaceport America, New Mexico

Boldly going where no one has gone before

SpinLaunch has an audacious plan to launch satellites with a giant centrifuge, and it might change the future of space flight, reports **Leah Crane**

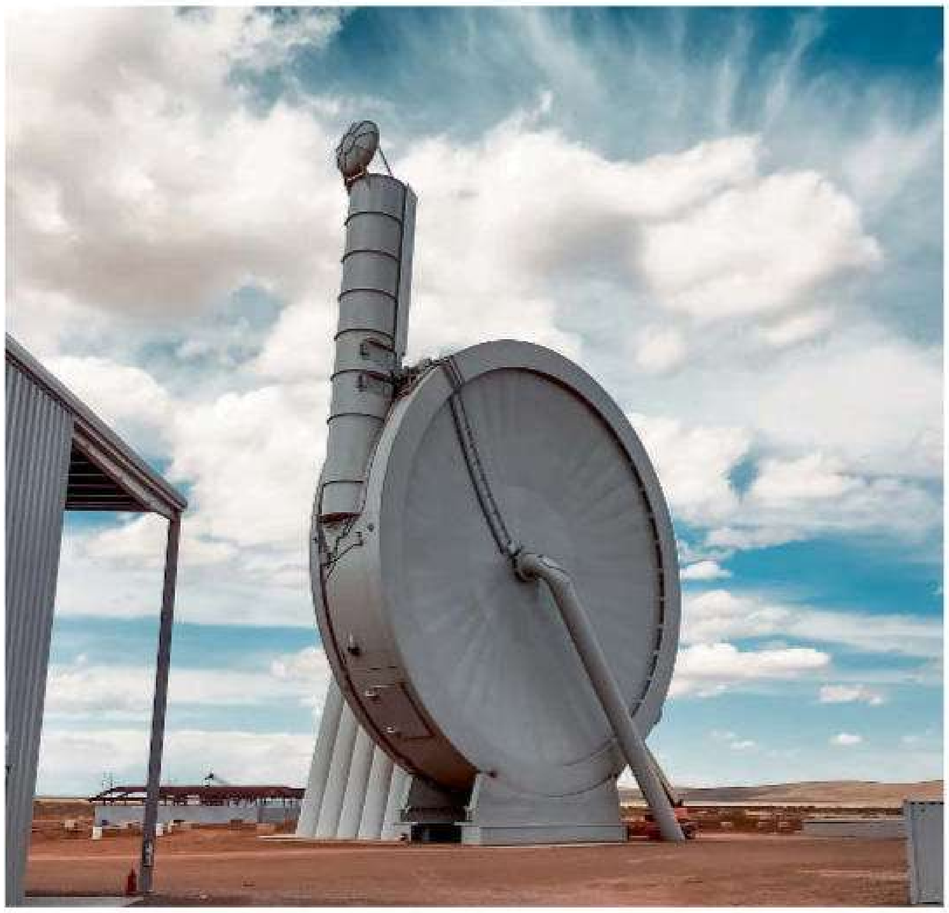
BUMPING along a dirt track in New Mexico, something alien rises above the expanse of brush. It looks like a flying saucer on its side, a huge circle 4 metres taller than the Statue of Liberty. This is SpinLaunch's suborbital accelerator, a colossal centrifuge built to practice throwing satellites into space. It seems like a wild idea, but it just might work, as I saw when I watched the company's ninth test flight.

SpinLaunch started in California in 2014 with the goal of making it cheaper and easier to launch satellites while reducing dependency on traditional rockets. In 2017, the company completed its first prototype centrifuge and began using it to test satellite parts, spinning them to extraordinary speeds to see if they could withstand the g-forces.

It went well, and the firm was starting to build the suborbital accelerator at Spaceport America when the covid-19 pandemic hit. Most of the construction and engineering crew moved into storage containers at the site, retrofitting them into living spaces and creating a small, isolated community in the desert where they holed up for two years.

On sunny days, people worked on the centrifuge, which was mostly made from off-the-shelf industrial equipment, some bought second-hand, rather than costly aerospace parts. On rainy days, they found other ways to keep busy – renovating the homemade village, exercising to stay fit for the gruelling work in extreme heat or tending their five chickens and two dogs. Every night there was music and a campfire. After more than two years, the hulking launch facility was ready.

The first test flight was conducted on 22 October 2021 and demonstrated a step towards a new idea: chucking things into space. This type of space flight would use mostly electricity rather than rocket fuel and could cost less than $500,000 per launch instead of upwards of $50 million. "The most complex, expensive and polluting part of space launch is the rocket," says Mark Sipperley at SpinLaunch.



SPINLAUNCH

The SpinLaunch centrifuge at Spaceport America in New Mexico

Inside the SpinLaunch centrifuge, the payload is enclosed within a carbon-fibre capsule, which is in turn attached to the end of a carbon-fibre tether. Almost all the air inside is pumped out to avoid aerodynamic friction and unnecessary heating. At the other end of the tether is a counterweight that keeps the whole system balanced while the tether whirls around, bringing the capsule up to speeds of thousands of kilometres per hour.

Then, all of a sudden, the tether releases the projectile and the counterweight. The projectile pierces the plastic sheet that is maintaining the centrifuge's near-vacuum and flies out of a chute pointed upwards. The counterweight is released into a canister of dirt, where it is vaporised nearly instantly.

When I visited SpinLaunch, I asked – only half joking – if I could get into the capsule and be flung to space. They said no. This system is for satellites only, because the g-forces from being spun around that fast would be fatal. Instead, I watched from a distance as the centrifuge flung its 3-metre-long projectile into the air at more than 1600 kilometres per hour. The process was eerily quiet – none of the usual rumbling of a traditional rocket launch – and after a few seconds, the projectile vanished into the sky. It flew more than 8000 metres up before crashing back down to the ground.

This system is only one-third of the size of SpinLaunch's planned orbital accelerator, which the firm aims to begin building later this year and finish in 2025. If all goes well, the orbital system will use 10-metre projectiles to send payloads of up to 200 kilograms into low Earth orbit – that is about eight cubesats or one satellite about the size of a washing machine.

1600

Speed in kilometres per hour that SpinLaunch's projectile travelled

And that is only the beginning. "Ideally, rather than building one orbital system, we would build them in farms… so we could pass power between the systems," says Sipperley. "Through regenerative braking we can capture back more than 80 per cent of the power of a launch [and feed it to a neighbouring system]."

SpinLaunch has contracts with NASA and the Pentagon, and the hope is to eventually perform five to 10 launches a day using the orbital system, all powered by renewable energy.

"The market expands when launch becomes cheaper – people that never thought they could send something to space will now be able to do it," says Christine Lawson at SpinLaunch. After seeing the suborbital accelerator in action, I believe it. It may not be able to throw me into space, but this little start-up might just revolutionise satellite launches. ■

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Analysis Artificial intelligence

Will text-to-speech AIs put illustrators out of a job?

Google's Imagen AI produces high-quality images from a text prompt, but is it ready to replace humans, asks **Alex Wilkins**

IMAGEN/GOOGLE

Six examples of images generated by Google's Imagen AI

TECH firms are racing to create artificial intelligence algorithms that can produce high-quality images from text prompts, with the technology seeming to advance so quickly that some predict that human illustrators and stock photographers will soon be out of a job. In reality, limitations with these systems mean it will probably be a while before they are available to the general public.

Text-to-image generators that use neural networks have made great progress in recent years. The latest, Imagen from Google, comes hot on the heels of DALL-E 2, which was announced by OpenAI in April.

Both models use a neural network trained on a large number of examples to categorise how images relate to text descriptions. When given a new description, the network repeatedly generates images, altering them until they most closely match the text based on what it has learned.

While the images presented by both firms are impressive, researchers have questioned whether the results are being cherry-picked to show the systems in the most favourable light, a common practice. "You need to present your best results," says Hossein Malekmohamadi at De Montfort University in the UK.

One problem in judging these AI creations is that both firms have declined to release public demos that would allow researchers and others to put them through their paces. Part of the reason for this is a fear that the AI could be used to create misleading images, or simply that it could generate harmful results.

The models rely on data sets scraped from large, unmoderated portions of the internet, such as the LAION-400M data set, which Google has said is known to contain "pornographic imagery, racist slurs, and harmful social stereotypes". The researchers behind Imagen say that as they can't guarantee it won't inherit problematic content, they can't release it to the public.

OpenAI claims to be improving DALL-E 2's "safety system" by "refining the text filters and tuning the automated detection & response system for content policy violations", while Google is seeking to address the challenges by developing a "vocabulary of potential harms". Neither firm was able to speak to *New Scientist* before publication.

Unless these problems can be solved, it seems unlikely that big research teams like Google or OpenAI will offer their text-to-image systems for general use. It is possible that smaller teams could choose to release similar technology, but the sheer amount of computing power required to train these models on huge data sets tends to limit work on them to big players.

Despite this, the friendly competition between the big firms is likely to mean the technology continues to advance rapidly, as tools developed by one group can be incorporated into another's future model. For example, diffusion models, where neural networks learn how to reverse the process of adding random pixels to an image in an effort to improve them, have shown promise in machine-learning models in the past year. Both DALL-E 2 and Imagen rely on the technique, after it proved effective in less-powerful models, such as OpenAI's Glide image generator. ■

Health

Immunotherapy for brain cancer can be made more effective

COATING a cancer drug with nanoparticles can help it cross the barrier that protects the brain from chemicals elsewhere in the body, enabling it to unleash an immune response that kills brain tumour cells. In a small study in mice, the encapsulated drug – used with radiotherapy – eliminated tumours in two-thirds of the animals.

Glioblastoma is an aggressive type of tumour that forms when brain cells called glial cells grow out of control. These tumours are usually treated with surgery, followed by radiotherapy and sometimes chemotherapy.

However, while some drugs have shown promise at boosting the body's immune response against brain tumours, the drugs often struggle to cross the blood-brain barrier to reach the tumour cells.

Maria Castro at the University of Michigan Medical School and her colleagues have now tested whether encapsulating a drug in synthetic nanoparticles – made with proteins found in the body – could help it reach the brains of mice.

The team injected mice with either a drug alone or a nanoparticle-coated version. Eight hours later, mice that received the coated treatment had three times more of the drug in their brains than mice given a normal dose.

Castro's team then tested how well the drug – with and without the nanoparticle coating – worked in mice that had tumour cells implanted into their brains.

"A combination of a coated drug and radiotherapy eliminated tumours in 67 per cent of mice"

A combination of the nanoparticle-coated drug and radiotherapy eliminated tumours in 67 per cent of mice, enabling them to survive for 90 days, on average, from the moment tumour cells were implanted. Mice that received either radiotherapy or the encapsulated drug alone died after about 60 days (*ACS Nanotechnology*, doi.org/gp7ndb).

The treatment still has to be tested to see if it works in other animal models of glioblastoma, before it could be tested in humans. ■

Carissa Wong

Materials

Dash of tomato colouring makes better solar panels

Alex Wilkins

THE chemical that makes tomatoes red could also boost the efficiency and stability of solar panels.

Most commercial solar cells are silicon-based, but a new generation of solar cells made from thin films of perovskite, a titanium and calcium crystal, promise greater efficiencies and are easier to work with. Yet perovskites degrade far faster than silicon-based cells, so improvements in stability are highly sought after.

Donglei Zhou at Jilin University in China and his colleagues chose to add lycopene, a pigment found in tomatoes and other red fruit and vegetables, to perovskite cells because they thought its powerful antioxidant properties might help slow degradation. The modified solar cells became more stable, losing about 8 per cent efficiency after 3500 hours, which is about six times better than standard devices, and were 3 percentage points more efficient at converting light to power.

"When UV is shone on human skin, [dietary] lycopene binds to free radicals produced by ultraviolet light to protect skin tissue from damage," says Zhou. "Therefore, we were curious whether lycopene has a similar effect on perovskite solar cells when exposed to ultraviolet and oxygen."

Zhou and his team think that, as well as binding with the perovskite to cut the amount of oxidation, the lycopene also improves efficiency by helping to reduce the number of microscopic grains in the perovskite's crystal structure, which improves the flow of electricity (*Advanced Energy Materials*, doi.org/gp7bcd).

A 3 percentage point increase in power conversion efficiency is pretty impressive, says Kyle Frohna at the University of Cambridge. "The devices they make in the end aren't the absolute best in the world, but the relative improvements from their control devices are pretty promising," he says. ▮

Science policy

UK talent visa blocks graduates from African universities

Jason Arunn Murugesu

A NEW UK visa aimed at attracting the best graduates from across the world risks excluding talent from African countries, scientists and policy-makers have warned.

The High Potential Individual visa, launched by the UK Home Office on 30 May, is aimed at people who have graduated in the past five years from one of what are often regarded as the world's top universities.

People with a recent undergraduate degree or PhD from such a university will be able to move to the UK for up to three years without needing to have a job lined up. Typical UK visas for foreign researchers require a pre-existing job offer, a fellowship, certain research grants or that the individual is a notable prize-winner.

The Home Office has drawn up a list of foreign universities it considers to be the best in the world by compiling institutions that appear in the top 50 at least twice across three specified global university league tables.

Scientists working in a medical research laboratory

LUIS ALVAREZ/GETTY IMAGES

The list includes no universities in African nations, effectively excluding anyone who has studied in Africa from the visa. There are also no universities in Central and South America or South Asia on the list.

"These ratings are based on criteria that favour universities which have been around for hundreds of years and have access to a lot of funding," says Amina Ahmed El-Imam at the University of Ilorin in Nigeria. "As someone from Nigeria who did their PhD in Britain, it's heartbreaking to see that there are still processes being put in place that inadvertently exclude Africans. Does this visa mean that there are no individual graduates from African universities with high potential?"

> **"Does this visa mean that there are no graduates from African universities with high potential?"**

"I think this is a deeply inequitable approach," says Christopher Trisos at the University of Cape Town in South Africa. "The exclusion of African universities strikes out many graduates with in-depth knowledge of major challenges facing humanity this century, such as climate change, food security and expanding access to technology."

If UK firms and government want to play a role in solving these challenges, they need to recognise the diverse skill sets held by many graduates from universities in low-income countries, he says.

Global university league tables have previously been criticised as a flawed way of measuring academic excellence.

"There is a wealth of evidence across social sciences that rankings produce a skewed idea of what constitutes quality in higher education and science, especially on a global scale," says Jelena Brankovic at Bielefeld University in Germany. "Making a new ranking by combining existing rankings does nothing else but create an illusion of an added layer of objectivity."

"I'm sceptical about it because 'top' universities and the best universities are not the same when it comes to teaching quality," says Nick Hillman at the Higher Education Policy Institute in Oxford, UK.

The Home Office didn't respond to specific questions about why the visa relies on a potentially flawed league table system or why it excludes graduates from African universities. "The new High Potential Individual route will make it as simple as possible for internationally mobile individuals at an early stage of their careers who demonstrate high potential to come to the UK," says Home Office minister Kevin Foster. ▮

Technology

Driverless cars could force other road users to drive more efficiently

Matthew Sparkes

AUTONOMOUS cars are predicted to improve fuel efficiency for everyone on the road – an idea that will be put to the test on routes around Nashville, Tennessee, later this year.

Benedetto Piccoli at Rutgers University, New Jersey, and his colleagues previously used a computer model of a simple circular road with just one lane in each direction, and found that autonomous cars could decrease overall fuel consumption of all traffic by 40 per cent, even when adoption of these vehicles had only reached 5 per cent.

In subsequent real-world tests that mimicked this set-up, they proved not only that autonomous cars were able to drive more smoothly than other vehicles, but also that they forced human drivers to do the same. This meant there was less bunching of traffic caused by sharp braking affecting following vehicles, something that leads to phantom traffic jams and lowered fuel efficiency.

The team has now designed a larger model that investigates how driverless cars will affect more complex and realistic road networks (arxiv.org/abs/2205.06913). Piccoli says it shows the efficiency benefits are likely to be lower, but still present.

That is because in a closed, circular system, a driverless car can make changes that propagate backwards through traffic and end up causing smoother traffic that benefits everyone, but on an open highway the cars will have a more limited influence.

Heavy traffic may flow more smoothly with driverless cars present

ANNA KRAYNOVA/SHUTTERSTOCK

The team hopes to carry out a large-scale, real-world test with 100 driverless cars from various manufacturers in Nashville later this year to verify the results of the new model.

The trial will have several phases, including one where the driverless cars act individually based on their programming, and one where they collaborate to ease traffic on a wider scale and share their own observations on traffic levels to a central server. "People will not even know they are in an experiment," says Piccoli.

His team hopes that this will reduce fuel consumption of all vehicles on the road during the trial – not just the driverless cars – by as much as 10 per cent.

"Reality is so complex and there's so much nuance and unpredictability," says Piccoli. "I'm not going to bet that we will reach that 10 per cent, but I hope that we will be able to show a really significant energy reduction. As you can imagine, if you take just the overall cost of the traffic system in any country, and you reduce that by even 5 per cent, we are talking about billions of dollars."

Tony Pipe at the University of the West of England in Bristol says the concept has the potential to improve fuel efficiency and travel times – but could also do harm if poorly implemented.

"It's a double-edged sword," he says. "If it can improve something, there's also potential for it to make things worse. It could generate lots of frustrated and irritated human drivers, who then act and do things that are not wise." ▮

Spacecraft

NASA backs rainbow-coloured solar sail project

FUNDING of $2 million has gone to researchers developing a new type of solar sail as part of NASA's Innovative Advanced Concepts (NIAC) programme, which backs projects that have the potential to transform future missions.

Generally, solar sails work by reflecting sunlight – each photon, or particle of light, that bounces off the thin, shiny material imparts a small amount of momentum to the craft. One big limitation is that if you want to move in any direction other than directly away from the sun, you have to rotate the entire sail, so such craft aren't particularly agile.

Amber Dubill at Johns Hopkins University in Maryland and her team have developed a solution to this drawback. They are working on a sail made of a diffractive material, one that can bounce light in various directions without having to be rotated. It does this via tiny ridges in the material, the orientation of which can be changed by running an electric current through the sail. The resulting sail would have a rippling rainbow appearance as the ridges act like prisms.

When the light bounces sideways, it would push the entire spacecraft to the side rather than directly forwards. "Even a small sideways kick turns out to be significant when you're trying to thrust in a direction that would be difficult or impossible to do by physically rotating the entire sail," says NIAC science adviser Ron Turner.

> "Usually, to move any direction other than away from the sun, you must rotate a solar sail"

Dubill and her team have proposed a mission on which to use their new solar sail. The spacecraft would use a sail to get to a polar orbit around the sun and observe its top and bottom, which is difficult to do with more traditional spacecraft.

The researchers plan to test various materials for how well they work in the sail and in space, while also developing trajectories and instruments for the solar mission. If all goes well, at the end of the two-year NIAC award the team will be ready to send a fleet of iridescent spacecraft around the sun. ▮

Leah Crane

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Birds

Maps show ecological toll of Japan's switch to farming

Christa Lesté-Lasserre

MORE than 70 per cent of birds – and a similar proportion of bird species – have disappeared in a region of Japan once occupied by hunter-gatherers and converted into farmland only a century and a half ago.

Until the 19th century, the Ishikari Lowland in north-west Japan was inhabited by hunter-gatherer communities. The Ainu, an Indigenous people in Ishikari, lived off salmon, deer, bear and edible plants. Agricultural landscaping, including systematic deforestation and drainage of wetland, only began in the region after the Japanese government stepped in. Today, most of the Ainu have been assimilated into Japanese society.

Munehiro Kitazawa at Hokkaido University in Japan wanted to know how native birds coped with the changes in Ishikari. "I couldn't stop imagining, 'How many wildlife species or individuals were there before broad-scale conversion to farmland, and how many have we lost?'" he says.

70%

Proportion of birds estimated to have vanished from Ishikari, Japan

Globally, scientists have lacked reliable data about the effects of agriculture on wildlife in the northern hemisphere because hunter-gatherer communities had vanished from many regions long before early researchers began documenting wildlife, he says. But Japan has kept fine-scale topological data on its territories since the 1850s – which covers the final years before Ishikari's conversion to farmland.

NATURE PRODUCTION/NATUREPL.COM

A great spotted woodpecker (*Dendrocopos major*)

Armed with this information, Kitazawa and his colleagues divided the 8400-square-kilometre Ishikari Lowland region into 2-hectare plots and studied the land cover of each one through time using maps from 1850, 1880, 1900, 1950, 1985 and 2016. Then, having determined the changes in land cover of each plot, they took advantage of a bird population model they had developed previously. This generates data according to land cover type, to estimate bird species and abundance.

The researchers estimate that forest-dwelling birds, including great spotted woodpeckers (*Dendrocopos major*), have lost approximately 90 per cent of their populations in Ishikari since the change in land cover. Wetland species such as reed buntings (*Emberiza schoeniclus*) experienced similar losses.

Although grassland species like Japanese quail (*Coturnix japonica*) increased in number at the start of the agricultural shift in Ishikari, they too were calculated to have declined by a net 68 per cent relative to their pre-agricultural numbers as the grasslands gave way to more croplands and housing developments in the 2000s, says Kitazawa.

Populations of birds that thrive on agricultural lands, including carrion crows (*Corvus corone*), are estimated to have increased by an average of 50 per cent in the region, says Kitazawa. Even so, the researchers estimate that the current bird abundance is less than a third of what it was prior to the switch to farming (*Proceedings of the Royal Society B*, doi.org/hwf2).

Laura Kehoe at the University of Oxford says it is "unique" to have "such an interesting case study" because of the scarcity of relevant data. "We just don't see this kind of story happening everywhere else, because so many areas have been converted so long ago," says Kehoe. ▮

Space

Bricks of moon or Mars dust are sturdy enough for buildings

Karmela Padavic-Callaghan

BRICKS made of salt water and moon or Mars dust can withstand enough pressure to be used in any future extraterrestrial construction.

Ranajay Ghosh at the University of Central Florida and his colleagues wanted to know if the dust and loose rocks on the moon and Mars, known as regolith, could be made into sturdy bricks. They tested two synthetic materials that mimic both types of regolith closely. First they mixed these materials with a solution of table salt and water, then 3D printed cylindrical bricks.

The researchers baked the bricks at various temperatures, then applied high pressure – simulating the stress of holding up a building. Some samples crumbled, but those that were baked at 1200°C held up better than even some regular, Earth-made bricks. The best of them withstood approximately 25 million Pascals, or 250 times the atmospheric pressure on Earth (arxiv.org/abs/2205.06855).

Off-world brick making would require ovens that could be heavy to transport or need lots of power. Ghosh says that one workaround may be to design ovens that focus and amplify heat from the sun, but that idea needs to be studied more.

Alan Whittington at the University of Texas at San Antonio says water will be rare off Earth and will probably be prioritised for drinking or farming. Power will also be limited, he says. ▮

Mare Crisium, a basaltic plain in an asteroid crater on the moon

NASA/GSFC/ARIZONA STATE UNIVERSITY

Health

Gene therapy on the rise

Having fallen out of favour in the 2000s, gene therapy is now helping children who would otherwise have died at a young age, reports **Alice Klein**

SHUTTERSTOCK/PAMMY STUDIO

Gene therapy works by replacing sections of DNA in the body

CHILDREN with some rare genetic conditions who would once have died at just a few years old could now have typical life expectancies due to gene-replacement therapy.

"We're curing kids of fatal diseases. It's wonderful," says Donald Kohn at the University of California, Los Angeles.

Kohn and his colleagues are trialling a gene therapy – in which disease-causing versions of genes are replaced by normally functioning versions – for leukocyte adhesion deficiency type-1 (LAD-1).

This rare condition occurs when immune cells called leukocytes can't travel to the site of a wound or injury, causing otherwise benign skin infections to become chronic. LAD-1 usually results in death before the age of 2, unless the child has a stem cell transplant.

The gene therapy works by replacing a mutated version of the *ITGB2* gene, which is responsible for LAD-1. Kohn and his colleagues take a child's stem cells from bone marrow and insert regular copies of the *ITGB2* gene using a virus that has been modified not to cause harm. They then use a low dose of chemotherapy to destroy the remaining bone marrow, and return the edited cells back into the child.

Since 2019, nine children have received *ITGB2*-replacement therapy, with their age at the initiation of treatment ranging from 5 months to 9 years. Now, none of those children experience chronic skin or lung infections and "they're leading normal lives, they're in school, they're off all their antibiotics", says Kohn.

This is just one promising clinical trial result for several gene-replacement therapies presented at the annual meeting of the American Society of Gene and Cell Therapy, held in Washington DC from 16 to 19 May.

Ewelina Mamcarz from St. Jude Children's Research Hospital in Memphis, Tennessee, presented positive results for a gene therapy for X-linked severe combined immunodeficiency (X-SCID), another rare immune condition that is usually fatal before the age of 2 without a stem cell transplant.

X-SCID is sometimes known as "bubble boy disease", because it only affects males, with these children previously having to isolate in plastic chambers to avoid infections.

> "They're all home with their families and they're no different to other kids"

This therapy replaces the abnormal version of the *IL2RG* gene that causes the condition, similarly using a virus to deliver normal copies of the gene into stem cells.

Since 2016, 23 infants with X-SCID have received the therapy when aged between 2 months and 14 months. All have now developed fully functional immune systems or are expected to as their treatment progresses, says Mamcarz. "They're all home with their families and they're no different to other kids," she says.

A gene therapy for another rare condition, infantile GM1 gangliosidosis – which progressively destroys nerve cells and is usually fatal before the age of 10 – was presented by David Weinstein from the US company Passage Bio.

Two children, aged 15 months and 31 months at treatment, received the therapy in March 2021. To replace the abnormal version of the *GLB1* gene causing their condition, Weinstein's team injected normal copies of the gene via a virus into cerebrospinal fluid in the backs of the children's necks. The virus then circulated around their brains and spinal cords, delivering the new genes.

The brains of children with GM1 gangliosidosis usually progressively shrink, but the younger child has displayed normal brain growth since the gene therapy. Both have also learned to walk and talk, which only some children with the condition ever achieve and they then lose the ability as their illness progresses. The older child has shown improvements, but not to the same extent as the younger one, possibly because he had more severe disease to begin with.

No side effects

None of the three gene therapies has caused any serious side effects to date. The only known treatment with the same effectiveness is a stem cell transplant. This requires a matched donor, which can be hard to find.

Stem cell transplants also run the risk of graft-versus-host disease, a potentially life-threatening complication that occurs when the transplanted cells attack the recipient's own cells.

In the early 2000s, gene therapies fell out of favour after some people receiving them developed leukaemia, but this was related to the particular mouse virus used to deliver the genes into cells, says Mamcarz.

Most groups now use an inactivated form of HIV to deliver the genes. It has been gutted so "it's just like a shell for carrying the genes into cells", says Mamcarz.

The treatment seems safe so far and there is no risk of them catching HIV from the inactive virus. However, all children who receive this virus will be carefully monitored for at least 15 years to check for increased cancer risk, which is a requirement of the US Food and Drug Administration for all gene therapies. ■

Gun violence

Firearm suicides are increasing in the US, despite declining globally

Grace Wade

RATES of suicide using a firearm have declined globally in the past three decades, but remain high in high-income nations. In the US, rates are lower than they ere in 1990, although they have been rising ever since 2006.

Irena Ilic at the University of Belgrade in Serbia and her colleagues analysed data from 204 countries and found that, between 1990 and 2019, the global rate of firearm suicide decreased by 2 per cent a year on average.

That fits within a broader global trend of falling suicide rates, says Paul Nestadt at Johns Hopkins University in Maryland. But the drop in gun-related suicides probably reflects tighter firearm restrictions. "There have been a variety of countries recognising the role of guns in suicide, and that is likely contributing to decreasing rates," says Nestadt.

Each year, more than 700,000 people worldwide die by suicide, according to the World Health Organization. More than three-quarters of suicides occur in low and middle-income countries. But for those suicides involving a firearm, rates are greatest in high-income countries, including the US, France, Canada, Switzerland, Finland and Norway.

23,365

Number of people who died from firearm suicide in the US in 2019

In the US, 23,365 people died from firearm suicide in 2019. That is 5.76 per 100,000 people, but just looking at men and boys, it is 10.13 per 100,000, according to the new analysis. China, Japan and Singapore have some of the lowest rates, with less than 0.03 firearm suicide deaths per 100,000 people.

Several studies have shown that stricter gun control laws are associated with lower rates of firearm suicide. For instance, before Australia passed legislation restricting firearm access in 1996, gun-related suicide rates were falling by an average of 3 per cent a year. After the laws were in place, they dropped by 7.4 per cent a year.

Austria saw a similar decline after the introduction of gun controls in 1997. Such measures have been shown to reduce firearm suicide rates in the US too.

Although such rates are lower in the US than they were in 1990, they have been rising since 2006, coinciding with growing access to guns. Since 2000, the number of firearms made each year has nearly tripled, according to a recent report from the US Bureau of Alcohol, Tobacco, Firearms and Explosives.

Because suicide attempts are often impulsive acts, access to guns increases the risk of death. A 2020 study that followed 26 million California residents for 12 years found that men who owned handguns were eight times more likely to die from firearm suicide compared with those who didn't. For women who owned a handgun, the likelihood increased to 35 times.

Of all suicide attempts, 8.5 per cent result in death. That rises to 90 per cent when a gun is used. Gun access doesn't mean someone will die by gun versus another method, says Nestadt, "it means someone will die by gun instead of surviving. And, importantly, for people who survive a suicide attempt, the vast majority never go on to die by suicide later."

Beyond access to firearms, childhood poverty, alcohol consumption and unemployment are also associated with firearm suicide, according to the analysis by Ilic and her colleagues (*PLoS One*, doi.org/gp7gcg). ▮

Need a listening ear? UK Samaritans: 116123 (samaritans.org). Visit bit.ly/SuicideHelplines for hotlines and websites for other countries

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Technology

Quantum computer does any calculation without errors

A QUANTUM computer made of charged atoms can catch its own errors when performing any operation – a meaningful step towards more reliable and practical quantum computers.

Conventional computers routinely flag and correct their own errors, so to truly outperform them, quantum computers will have to do the same. However, quantum effects can make errors cascade quickly through the qubits, or quantum bits, in these devices.

Lukas Postler at the University of Innsbruck in Austria and his colleagues have now built a quantum computer that runs any calculation without errors.

Any operation of a quantum computer can be broken down into simpler computations called quantum gates. These can be applied to a qubit by hitting it with a laser to change its quantum state. The researchers created a set of gates that are building blocks for more complicated computations and that keep even the most complex of them error-free.

They used electric fields to trap 14 calcium ions in place, forming two so-called logical qubits, each made of seven entangled ions. Two more qubits served as "flags" that let the computer know when some erroneous computation needed to be corrected (*Nature*, doi.org/gp7f68).

CHRISTOF LACKNER/UNIVERSITY OF INNSBRUCK

A vacuum chamber where ions are trapped to form a quantum computer

"With this universal set of gates, you can approximate every calculation that you can possibly want to do with a quantum computer," says Postler. The researchers demonstrated that each of the logic gates within their system works, reducing the errors.

While this set-up would be useful for certain quantum computers, it may not work for more complicated systems, says Christopher Monroe at the Joint Quantum Institute in Maryland. For quantum computers that use superconducting qubits, such as Google's Sycamore, error correction from the get-go requires devices much larger than 16 qubits, he says. The new quantum computer isn't yet big or reliable enough to tackle any practical real-world problem, he adds. ▮

Karmela Padavic-Callaghan

CRISTIAN UMILI/MONDADORI PORTFOLIO VIA GETTY IMAGES

Wildlife

Romans may have set rare seals on the path to peril

THE rarest seal species in the world started its population decline millennia ago, possibly due to the rise of ancient human civilisations.

Mediterranean monk seals (*Monachus monachus*) are very endangered. Once widespread throughout the Mediterranean Sea, Black Sea and warmer North Atlantic coastlines, there are currently only a few hundred left in disjointed populations.

Previous research has shown that these groups have low genetic variation, leaving them susceptible to disease and other threats. But it wasn't clear precisely how these seals became so vulnerable.

Jordi Salmona at the Paul Sabatier University in France and his colleagues sought to answer this by delving into the animals' genetics. They collected DNA from samples of the skin, hair, faeces and bones of 383 monk seals, from both current and extinct populations. After analysing the DNA, they used models to infer the timing of past drops in the number of seals and their genetic diversity.

They found many monk seal populations shrank to a tenth or less of their original size between 800 BC and AD 600 – a period that saw the rise of civilisations and widespread seafaring in the Mediterranean basin.

The researchers suspect that hunting by people may have baked diminished genetic diversity into the future of the seals. The team points to the Roman Empire's exploitation of wildlife at this time, which we know led to localised extinctions of other species (bioRxiv, doi.org/hwjd). **Jake Buehler**

Astronomy

Stellar puzzle settled by an unlikely source

A WEATHER satellite may have solved the mystery of why the star Betelgeuse briefly lost its shine.

In late 2019, the red supergiant star, which is about 550 light years from Earth, suddenly became a lot fainter, an event known as the Great Dimming.

Previous research had suggested a cloud of dust and a cool spot on the star may have been the cause. Daisuke Taniguchi at the University of Tokyo, Japan, now believes we know for sure thanks to an unlikely source: a satellite designed to monitor weather on our planet.

The satellite – Himawari-8 – is used to observe weather in Japan and nearby regions from a geostationary orbit nearly 36,000 kilometres up. However, it also occasionally sees stars appear beyond the edges of Earth – including Betelgeuse once per day.

Taniguchi used publicly available data from the satellite to get regular infrared observations of the star from 2017 to 2021. These allowed him to confirm the cause of the Great Dimming, which ended in early 2020. There was indeed a cloud of dust, picked up by the satellite's instruments, and the temperature of the star also dropped by 140°C (*Nature Astronomy*, DOI: 10.1038/s41550-022-01680-5).

The cause of the dust isn't clear. It may have been a shockwave in the star that expelled gas that then condensed into dust. This could also explain the cooling of the star, although it isn't yet certain if the events were related.

Taniguchi already has plans to use Himawari-8 to observe more stars, to examine their evolution and dust production, and other weather satellites could be useful too. "I hope after the publication of this paper, other satellites will publicly open their data," he says. **Jonathan O'Callaghan**

Health

Lifestyle can counter genetic dementia risk

PEOPLE with a high genetic risk for dementia can reduce their chance of developing the condition via a healthier lifestyle, a study suggests.

Adrienne Tin at Johns Hopkins University in Maryland and her team used data from more than 11,000 people in the US. They had an average age of 54 at the start of the study and were followed, on average, for 26 years. Of these, 8823 were of primarily European descent and 2738 primarily African descent. Each was scored on seven health factors: smoking, diet, weight, physical activity, and control of blood sugar, cholesterol and blood pressure.

Changes to these factors, promoted as "Life's Simple 7", are known to maintain good heart health. Previous studies have shown this can also cut the risk of developing dementia, says Tin. In the study, the team wanted to see if this was still true for those most at risk of dementia due to genetics.

The researchers assessed each person's genetic risk for dementia and found that people of primarily European descent in the highest genetic risk group could cut their dementia risk by 8 per cent for each point they increased their healthy lifestyle score on a 14-point scale (*Neurology*, doi.org/hwjr). They saw similar results for people of primarily African descent, but the smaller sample size means that conclusion is less certain, says Tin. **Jason Arunn Murugesu**

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Really brief

ANDY SANDS/NATUREPL.COM

British butterflies are under threat

More than two-fifths of butterfly species in Great Britain are at risk of extinction. Four species out of the 62 assessed by the UK charity Butterfly Conservation are already regionally extinct, and 24 of the remaining 58 are classed as either endangered or vulnerable to being lost (*Insect Conservation and Diversity*, doi.org/hwjk).

Richest homes have higher wildfire risk

The most valuable homes in the western US are 70 per cent more likely to be at high risk from wildfires than median-valued properties. High-income, white and elderly communities are also disproportionately at risk (*Environmental Research Letters*, doi.org/gp7kc9).

Lake Erie pollution could get worse

Efforts to curb algal blooms in Lake Erie may make the water more toxic. The lake is on the US-Canada border and both nations have focused on phosphorus run-off from farms, but if nitrogen isn't reduced as well, toxins in the lake could actually rise (*Science*, doi.org/gp7nxt).

Materials

Graphene made from old bumpers

OLD plastic from scrapped cars can be converted into graphene by grinding it to dust and zapping it with high-voltage electricity, a process that could save large amounts of plastic from landfill.

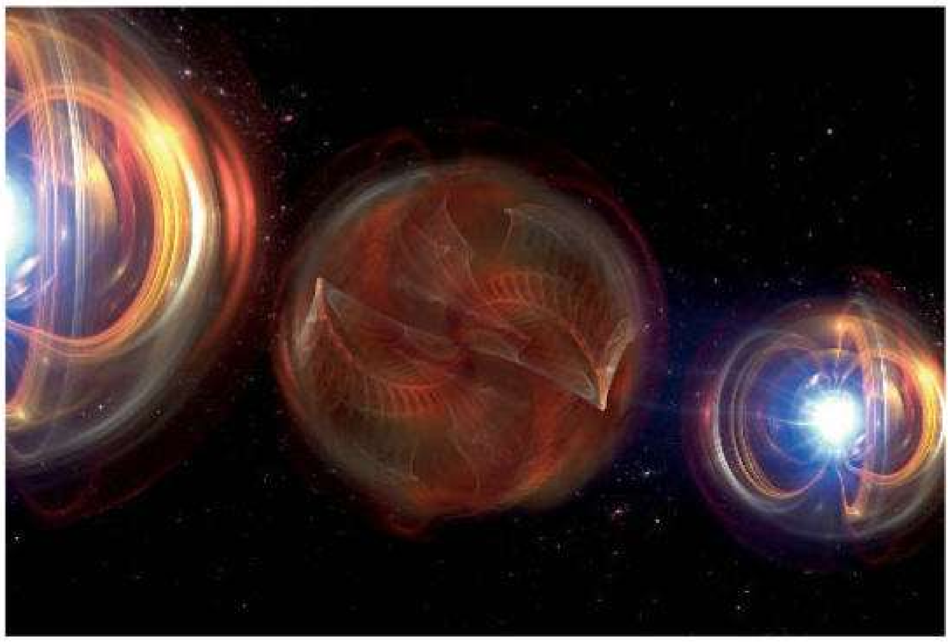
Graphene is a form of atom-thick carbon with a number of useful electrical and material properties. James Tour at Rice University in Texas and his team have previously found that plastic could be converted into graphene via a process called flash joule heating, where material is heated to temperatures generally in excess of 2700°C by passing high voltages through it.

They have now worked with car manufacturer Ford to show that this graphene can be used to make new parts for cars, and that those new parts can again be recycled into fresh graphene.

Tour and his colleagues take plastic waste that has been ground down into particles around a millimetre in diameter. Their flash joule process turns any carbon present into graphene, while also simultaneously vaporising any other elements (*Communications Engineering*, doi.org/gp7nqs). The yield is dependent on the amount of carbon present: high-density polyethylene contains 86 per cent carbon by mass, whereas polyvinyl chloride contains just 38 per cent.

He says certain plastic parts of cars, such as the bumpers, could be repeatedly recycled to avoid waste. An increasing amount of the plastic used in cars contains graphene, which adds several desirable properties, such as higher strength. **Matthew Sparkes**

Technology


JURIK PETER/SHUTTERSTOCK

'Teleportation' achieved in miniature quantum network

A QUANTUM network can teleport information between unconnected nodes – an important step towards building a secure quantum internet.

Objects that share a quantum entanglement have linked properties. This is central to ideas for a quantum internet. One idea is to build a network of connected quantum bits, or qubits, that are entangled with qubits elsewhere in the network rather than with their direct, neighbouring nodes.

Ronald Hanson at Delft University of Technology in the Netherlands and his team have built a simple network containing a number of diamond-based qubits arranged into three nodes, dubbed Alice, Bob and Charlie. There was no direct connection between Alice and Charlie, only an indirect link each shared with Bob. But Alice and Charlie were quantum entangled. When Charlie's quantum state was changed, Alice's also changed, meaning information "teleported" across Bob rather than passing through it (*Nature*, doi.org/gp7gfx).

A quantum internet network wouldn't be speedier despite its apparent instant exchange of data because users must also link up via non-quantum communication. But it would offer eavesdropping-proof communication. **Alex Wilkins**

Robotics

Micro machine can climb through body

A TINY robot with a soft, flexible body and spiky feet can climb the moist, slippery inner walls of the lungs and gut, where it could one day deliver drugs.

The new "millirobot" is a few millimetres long and has feet that stick to tissue surfaces without losing grip. The robot resists being dislodged by jarring movements and can cling to a surface as liquids are flushed over it in a similar way to movement of fluids associated with breathing and digestion.

The device, controlled by magnetism, is "a significant milestone in soft robotics", says team member Metin Sitti at the Max Planck Institute for Intelligent Systems in Germany.

The robot has two spiked footpads. Once one is down, the robot pulls its other foot off the surface and flips its body over to take a "step". When covered with a layer of chitosan, a substance found in shrimp shells, the foot's "microspikes" created just enough friction and stickiness for the feet to latch on to the mucus layer in pigs' lungs and digestive tracts – including the bronchial tubes and intestines – and then pull away to take a new step (*Science Advances*, DOI: 10.1126/sciadv.abn3431). **Christa Lesté-Lasserre**

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We're Glaucoma UK.
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Supporting people with glaucoma now, and in the future

Over 700,000 people in the UK have glaucoma, and half of them don't know they have it. Between 2015 and 2035, the number of people living with the disease in the UK is expected to increase by 44%.

WHAT IS GLAUCOMA?

Glaucoma is the name of a group of eye diseases that damage the optic nerve. The optic nerve transfers visual information from the eye to the brain and if it's damaged, it can result in sight loss and even blindness.

Glaucoma can often be symptomless, which means that much damage can be done and significant vision lost before a person realises there is a problem. For most people, the signs of glaucoma are first spotted during a routine eye test.

Although any vision which has been lost from glaucoma can't be recovered, with early diagnosis, careful monitoring and regular use of treatments, most people with glaucoma can retain useful sight for life.

WHO IS MOST AT RISK OF GLAUCOMA?

While anyone may develop glaucoma, some people are at a higher risk, including those with a family history of the disease. Glaucoma is fairly rare below the age of 40, but the risk rises over the age of 40 and continues to increase as we get older. One in 10 people aged 75 or over are affected by glaucoma. People of African-Caribbean origin are also four times more likely to develop the disease than people of European origin.

With an ageing population and modern technology making earlier detection possible, more and more of us will find ourselves affected by glaucoma. If you are living with glaucoma, you are not alone; Glaucoma UK is here to help you.

ABOUT GLAUCOMA UK

Glaucoma UK is the charity for people with glaucoma. We campaign to raise awareness so that glaucoma is detected early and can be treated, we support people to live well with the disease and we fund sight-saving research. Our aim is to end preventable glaucoma sight loss. We provide a range of free services to help people living with glaucoma, and everyone who cares for them.

How can you help

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Comment

Lessons from space

There is much we can learn from space exploration to help secure a more sustainable food system on Earth, argues **Angelo Vermeulen**

IN 2013, I lived in Hawai'i on the side of the Mauna Loa volcano, locked in a habitat with five other engineers and scientists to act out life on Mars for 120 days. I was crew commander of HI-SEAS I, the first NASA-funded Hawai'i Space Exploration Analog and Simulation mission.

Our main scientific work was a food study, investigating whether cooking with shelf-stable ingredients, such as freeze-dried meat and dehydrated vegetables, could combat a phenomenon called menu fatigue – which is a loss of appetite caused by repeated consumption of pre-prepared meals. Ours went down a treat.

The environment of space forces us to be resourceful. The International Space Station is about 400 kilometres from Earth, so regular resupply is feasible but costly. Once humanity ventures deeper into space, a more radical approach to sustainability will have to be embraced. Applied back on Earth, such an approach could also profoundly ease terrestrial food security challenges.

The world's food systems are already under significant strain because of covid-19, and Russia's invasion of Ukraine has become another threat to global food security. Big challenges need innovative solutions. And, as improbable as it might seem, space exploration might actually help to secure our food future – contributing to a more sustainable and resilient global food system.

SIMONE ROTELLA

In space, rather than depending on resupplies, we need to learn how to grow significant amounts of food with a circular approach. This means capturing human waste and breaking it down into nutrients for crops and other edible organisms, while at the same time using it to provide oxygen and fresh water. I call this "molecular sustainability".

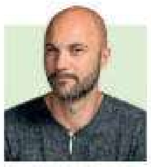
An example of such a "closed loop" system is the Micro-Ecological Life Support System Alternative (MELiSSA) program, managed by 14 partners including the European Space Agency. It is a minimal ecosystem comprising five compartments that are inhabited by different organisms. Each compartment has its own specific metabolic function, and human waste gets broken down through a sequence of bioreactor types, each inhabited by different microorganisms.

MELiSSA is developed by a consortium of more than 50 organisations. There is currently an operational pilot plant at the Autonomous University of Barcelona in Spain that connects a number of compartments, with rats used as proxies for astronauts. Their urine and carbon dioxide get recycled and used to grow crops and edible microalgae.

This molecular sustainability, in which every molecule counts, stands in stark contrast to the food waste problem here on Earth. Every year, 1.3 billion tonnes of food are wasted – roughly a third of global food production. This is unjustifiable, especially when we are developing extraterrestrial systems that are aiming to be so efficient. We might never eliminate all food waste on Earth, but by using concepts from space, we should be able to significantly reduce the amount.

Collaborations such as the Global Food Safety Initiative are crucial to driving the scale and pace of change we need. This coalition brings together the food industry's biggest retailers and manufacturers to oversee food safety standards for businesses, and it helps provide access to safe and sustainable food for people everywhere. At its recent conference, I spoke about what we can learn from space to improve food security on Earth, hoping to inspire experts from business, government and academia.

Sometimes, taking a step away from Earth can help us see things more clearly. It is by considering our life as a whole, both on and off this planet, that we will be able to create a more resilient food future for all of humanity. ▮



Angelo Vermeulen is a space systems researcher, biologist and artist

My botanical life

Time to smell the roses

While botanical gardens have evolved from their medicinal roots in 16th-century Italy, their plants can still bring peace and joy today, says **Beronda L. Montgomery**

Beronda L. Montgomery is a writer, researcher and biochemist who studies how plants detect and respond to their local light environment. She is the author of *Lessons from Plants*. You can follow her on Twitter @BerondaM

ONE of my favourite ever pastimes is to visit botanical gardens. In almost every city I go to, I make time to wander and linger among plants.

My local botanical gardens, the Frederik Meijer Gardens & Sculpture Park in Michigan, are a plant and art lovers' haven. While you might think that a trip to a particular garden would be an infrequent event, I love to visit multiple times a year, enjoying the pink swamp milkweed and black-eyed Susan flowers supporting the butterflies in spring, and the yellow, orange and purple chrysanthemum flowers in autumn.

Whether the trees are bare, surrounded by just a few winter plants and shrubs, or birches with their distinct white trunks fully enrobed in mature summer leaves and providing a robust background for the gardens' beautiful sculptures, I observe and am inspired. One of my favourite places is among the red maples in the Japanese garden in the height of autumn colours.

The joy of walking through familiar grounds is equalled by the excitement of exploring new gardens when I travel. Many a day in places around the globe starts with an eager exploration of new gardens, followed by finding a bench in a plant-surrounded enclave to reflect and write.

My most recent venture was in early May in the heart of Vienna, Austria, where I visited both the Burggarten, once the private gardens of Emperor Franz Joseph I, and the Volksgarten, or "People's Garden", for commoners. The Volksgarten houses a beautiful rose garden and an impressive memorial site to Empress Elisabeth of Austria.

A local tour guide highlighted the origins of the Volksgarten as a place for commoners to visit, and as critical to maintaining the exclusivity of the royal family's gardens for their private use.

This might align with perceptions of these spaces as somewhat exclusive. But this isn't the origin of modern botanical gardens, which are generally traced to the appointment of professors of botany to the medical faculties of universities in Italy during the 16th century.

These botanists were stewards to curate physical gardens housing medicinal plants. The gardens served as a pharmacy of sorts, where the curating botanists possessed pharmaceutical knowledge of the potential uses of plants as medicines and elixirs, i.e. pharmacology.

> **"The joy of walking through familiar gardens is equalled by the excitement of exploring new ones when I travel"**

Botanical gardens also have deep roots that parallel the Austrian Burggarten, with royal gardens emerging early as signs of wealth and leisure or health. Some of these royal gardens housed rare species, including ornamentals, that were brought back to Europe from plant expeditions into places such as India and countries in Asia and Africa. Many are now open as public or tourism sites.

The botanical gardens we know today, which serve as public (or at least affordable) spaces designed to showcase plant diversity, and to facilitate conservation and public botanical education, came from these medicinal and royal roots.

Their origins are also associated with the emergence of densely populated towns and cities. People had fewer opportunities to engage with plants as these industrial cities expanded globally, and botanical gardens were intended to provide public education about diverse plant species, as well as leisure opportunities in plant-rich environments.

This promotion of engagement in green spaces drove the expansion of botanical gardens ranging from tree-rich arboretum spaces to desert species-focused gardens in arid climates to hybrid community-centred spaces.

The sculpture park that is combined with the botanical gardens at Meijer certainly draws art enthusiasts as much as plant lovers. Today, these spaces also house concert stages and venues for weddings and parties, attracting a diverse audience.

Although the closing of lots of public spaces during the covid-19 pandemic posed challenges to botanical gardens, many used digital technology to promote engagement at a distance. They have also grown their focus on community and citizen science programmes to increase relevance and engagement in recent years, and many botanists are also trying to use them as opportunities to contribute to important conversations and research about climate change.

Frequently, when asked how to cultivate interest in plants for those living in cities and with busy lives, I point to time in accessible botanical gardens.

While the current spaces have evolved from their medicinal roots, they still hold great power for promoting health and wellness in many forms, including the emotional peace and joy found in engaging with beautiful plants from all walks of life. ▮

Beronda's week

What I'm reading

I'm absorbing what we can learn from complaints about abuses of power in Complaint! *by Sara Ahmed.*

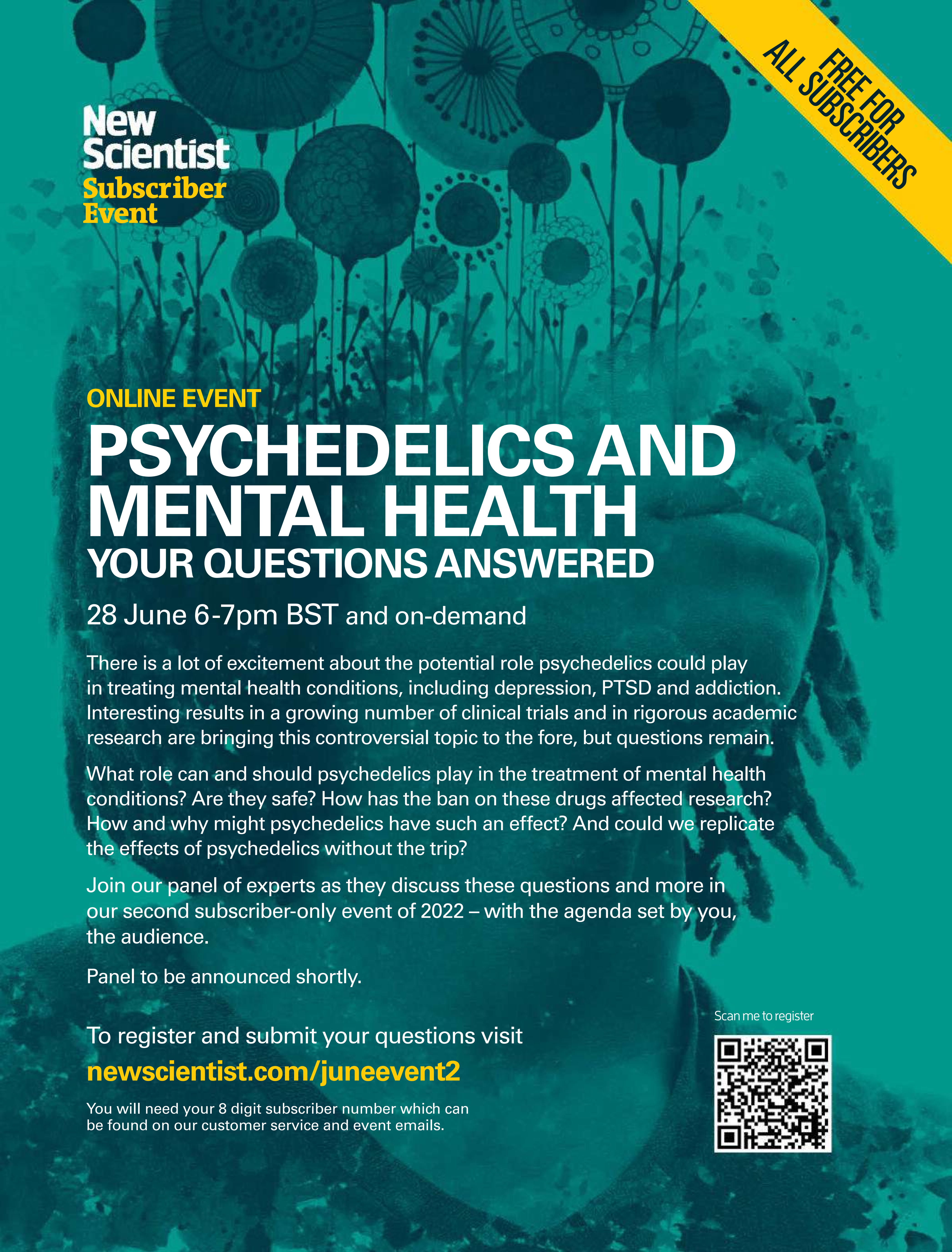
What I'm watching

Wild Babies, *a Netflix nature documentary.*

What I'm working on

I am collaborating on completing and submitting a manuscript on mentoring ecosystems.

This column appears monthly. Up next week: Chanda Prescod-Weinstein



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There is a lot of excitement about the potential role psychedelics could play in treating mental health conditions, including depression, PTSD and addiction. Interesting results in a growing number of clinical trials and in rigorous academic research are bringing this controversial topic to the fore, but questions remain.

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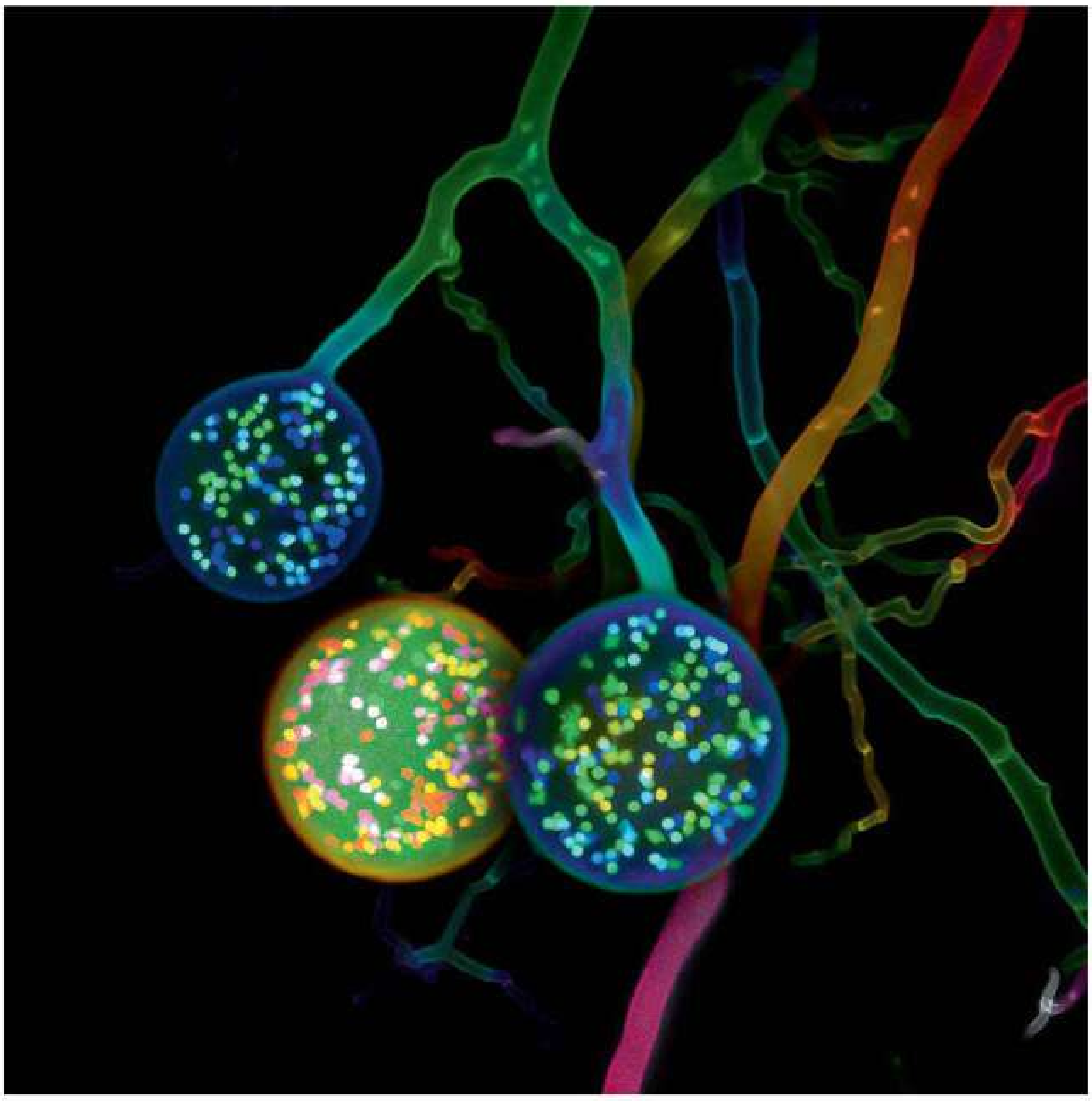

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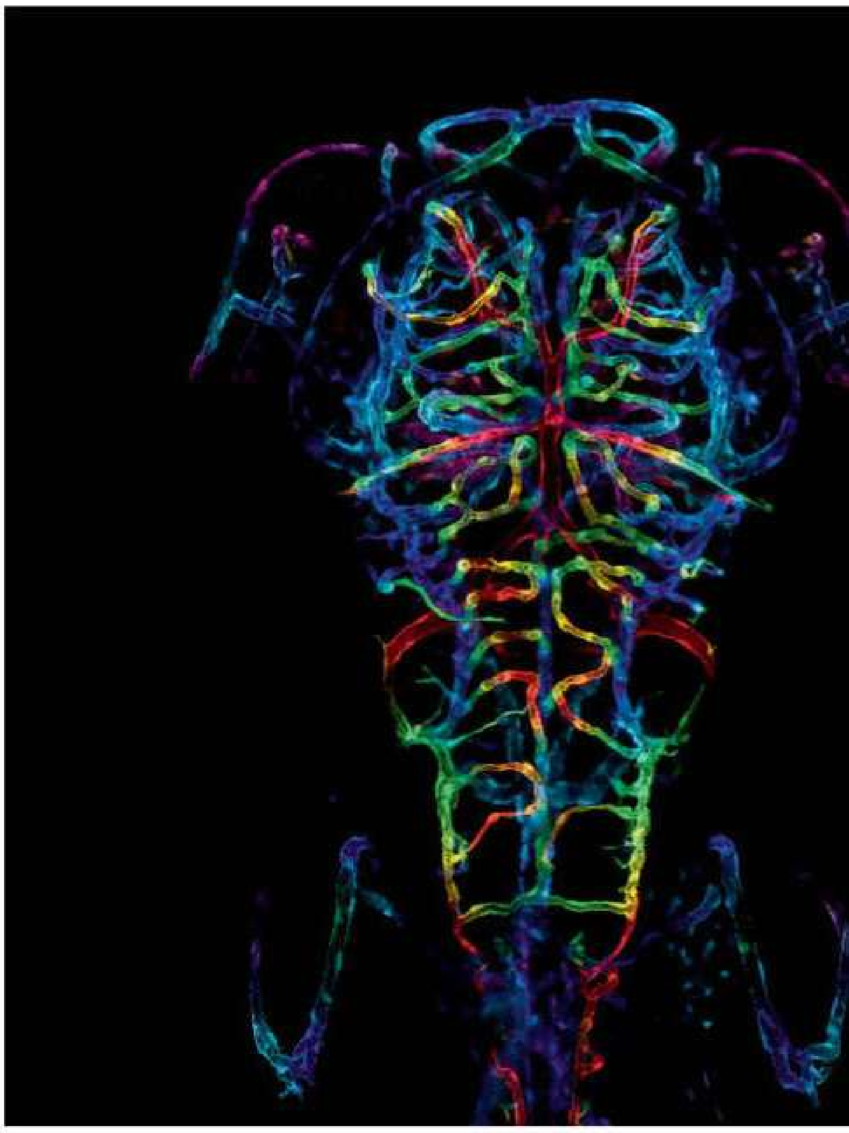

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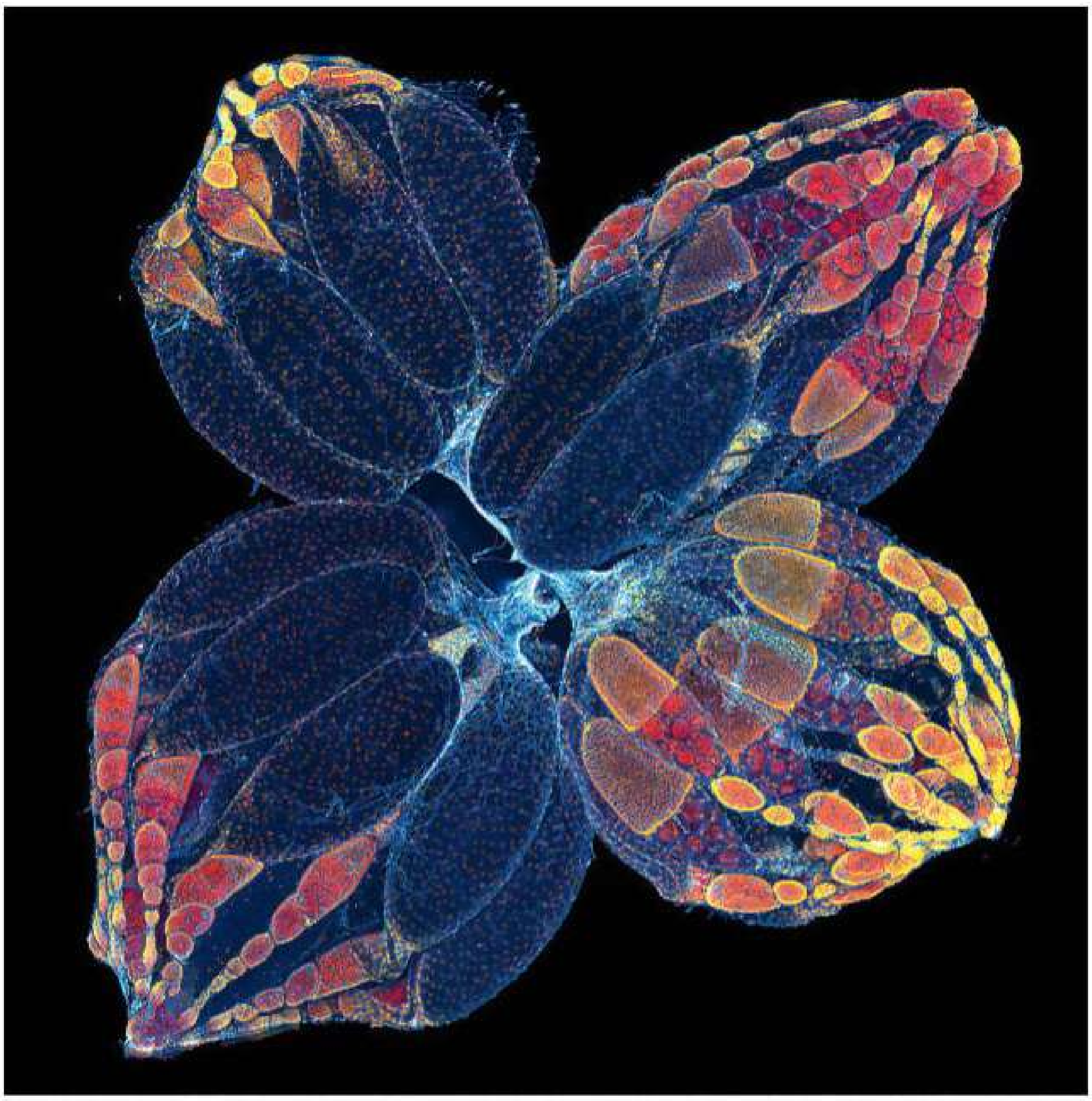

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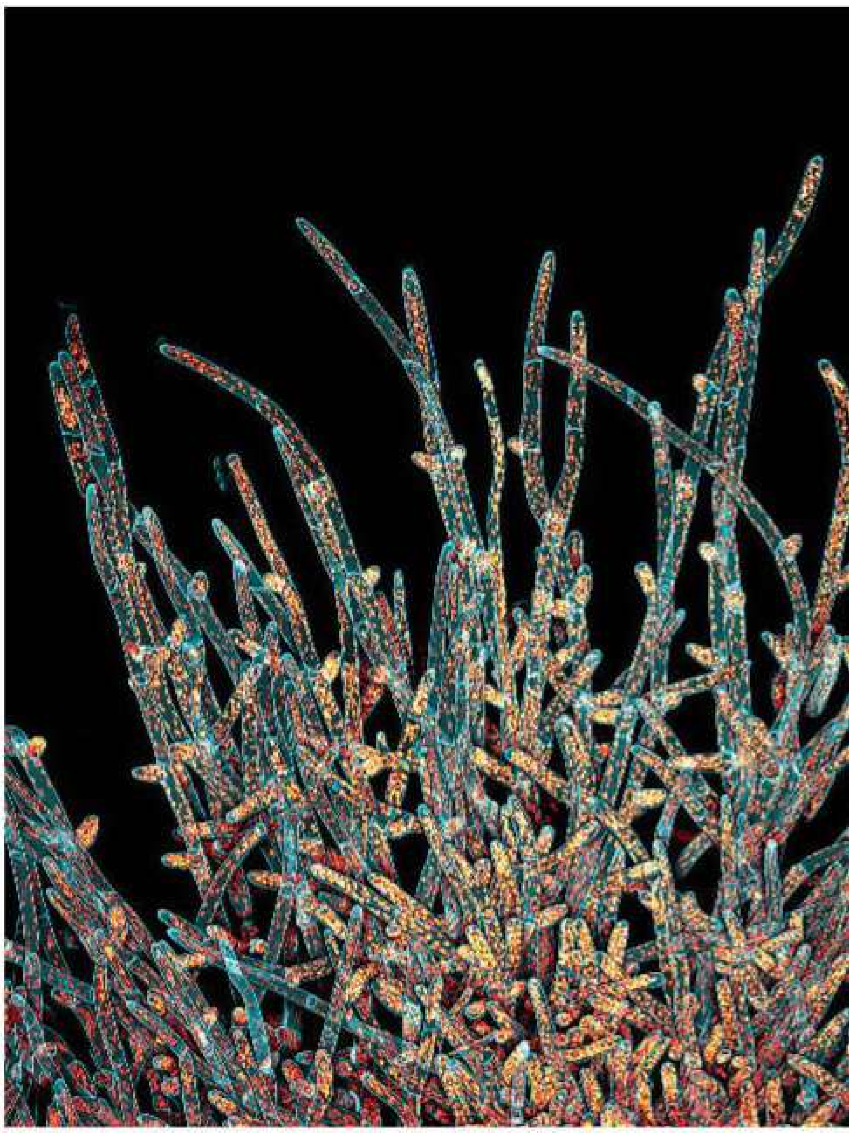

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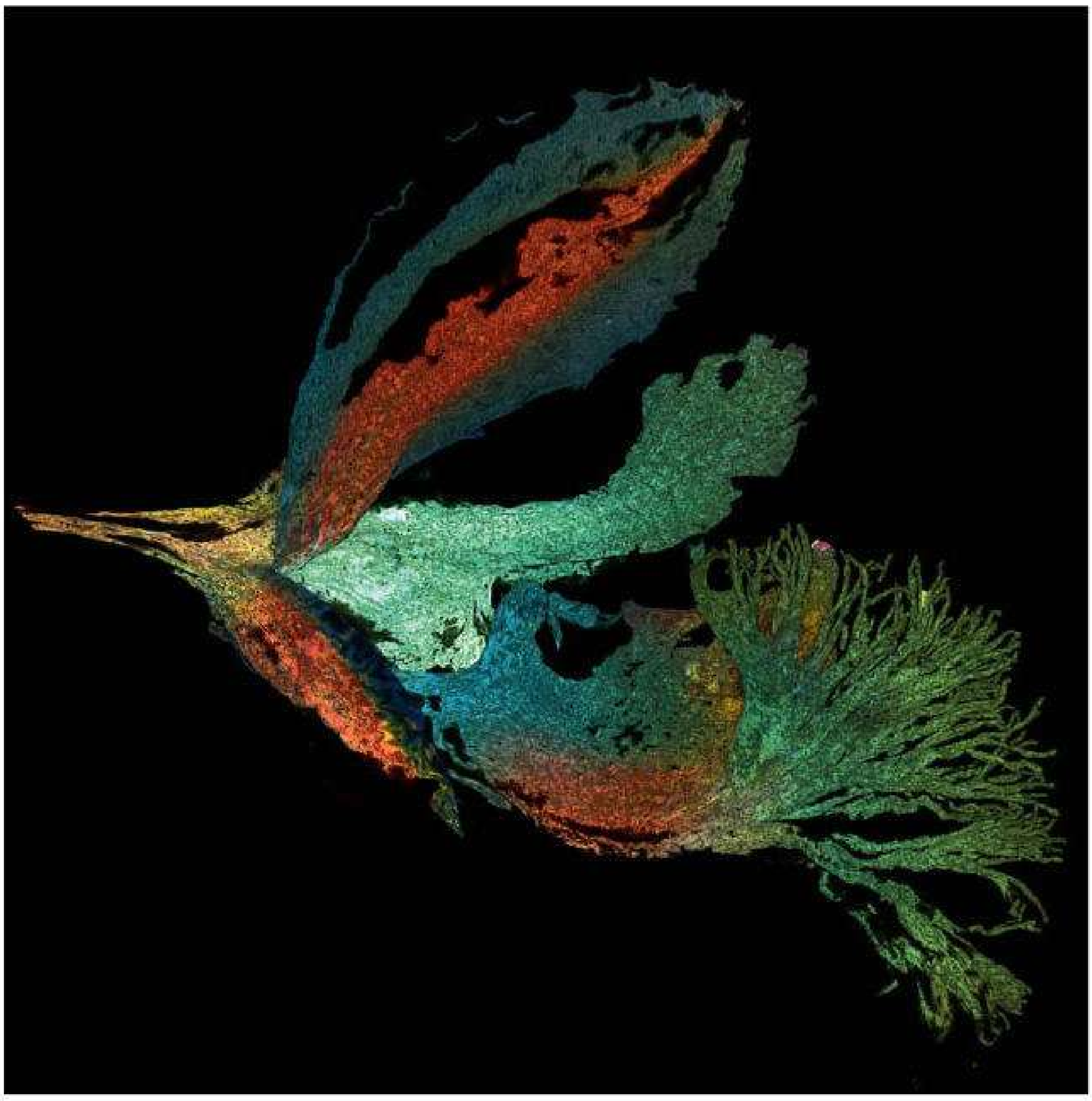

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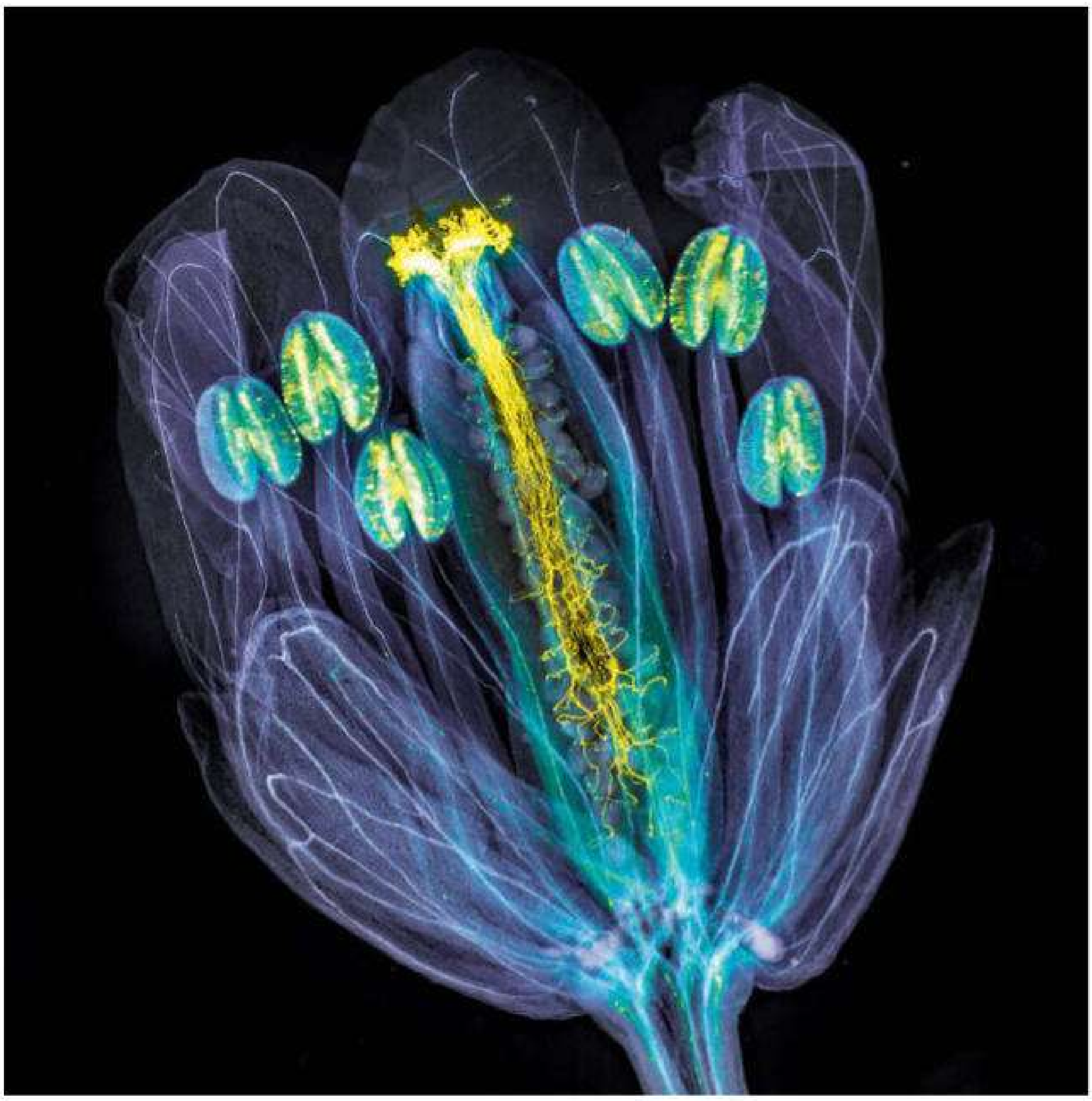

JAN MARTINEK

In the details

THESE dazzling images, each captured with an optical microscope, hold a lens up to the natural world, revealing the beauty and richness of an up-close perspective. They make up some of the winning and shortlisted entries for the Olympus Image of the Year Global Life Science Light Microscopy Award, an international photography competition showcasing the art of scientific imaging.

The top row shows (left to right): an arbuscular mycorrhizal soil fungus cell containing hundreds of nuclei, unlike typical cells that carry just one nucleus, which won Vasilis Kokkoris the regional prize for Europe, the Middle East and Africa; the axons in the developing nervous system of a zebrafish embryo, which earned Layra Cintron-Rivera an honourable mention; and a Siberian milkwort plant captured by Mingyue Jia, another of the competition's honourable mentions.

The bottom row shows (left to right): the ovaries of a fruit fly, an honourable mention taken by Yujun Chen; Ivan Radin's winning image for the Americas region of *Physcomitrium patens* (commonly known as spreading earth moss), a model organism for studying plants; and the competition's global winner, captured by Jan Martinek, of the flower of *Arabidopsis thaliana* (or thale cress), another plant model organism that Martinek made chemically transparent to reveal the stained pollen tube within, shown in yellow.

Gege Li

Editor's pick

Only degrowth can save the global climate now

Leader, 21 May

From Bryn Glover, Kirkby Malzeard, North Yorkshire, UK

I welcome your editorial highlighting the lack of progress on climate change. It is true that other global problems have made progress more difficult, but it seems that many world leaders have seized upon these factors as an excuse to delay or cancel their promised actions.

Often, they place national or political interests first, or invoke the need for economic growth to solve such problems. This clearly shows that most of them still don't get it. Far from economic growth, we need degrowth. Conventional economists will condemn this, but the simple truth is that, globally, we must aim to consume radically less than we do at present.

Leaping to the defence of Solly Zuckerman

7 May, p 42

From James Austin, Wagga Wagga, New South Wales, Australia

Solly Zuckerman, referred to as "the discredited 20th-century British zoologist," was, in fact, a remarkable man and polymath.

After a medical degree at University College London, he chose to lecture in anatomy at Oxford, where he was an early proponent of the idea that egg development in mammals is largely completed before birth. This idea is now widely accepted, though not without controversy.

During the second world war, his anatomical expertise was sought to study the physiological and psychological effects of bomb blasts, resulting in him becoming an adviser on strategic air raids. He strongly opposed civilian bombings. In the process, he also become a pioneer of what was then called operational research, the basis for modern management science. After the war, he promoted science in public policy and opposed nuclear arms proliferation. He also encouraged public scientific literacy and urged scientists to consider the social and environmental impacts of their work – values that, I suspect, *New Scientist* readers and writers would endorse.

We fight for climate on all fronts, Brazil included

Letters, 7 May

From Christophe Bourges, Cambridge, UK

Following an article on the destruction of the Amazon, John Neimer commented that Extinction Rebellion (XR) should target the Brazilian embassy in the UK, instead of "disrupting ordinary citizens' lives".

XR is an international movement and is fighting in Brazil against deforestation and other issues, alongside similar groups. In the UK, where most forests have already been felled, the average citizen's carbon footprint is about 10 tonnes (carbon dioxide equivalent), whereas it should be around 2 tonnes to be sustainable, meaning there is a lot of room for local improvement.

Questions on the bug splat method for insect health

14 May, p 23

From John Corey, Melrose, New York, US

Your report states that bug splats on UK cars declined by 58 per cent per car-mile travelled between 2004 and 2021, and suggests that this was due to declining bug numbers. Would it not also be dependent on traffic density? That is, if the number of car-miles driven had doubled, in a world with constant bug levels, then the splat count per car would surely fall by nearly as much.

From Peter Reid, Plymouth, Devon, UK

When it comes to bug splat counts, can we take it that allowance has been made for more aerodynamic cars in the past 17 years? Or the increased numbers of taller cars, SUVs in particular?

Do ancient martial arts tap into our fascia?

14 May, p 38

From Richard Hind, York, UK

The article "Your second skin" provides a very insightful overview of current research into fascia tissue. I was intrigued by the suggestion that it could be classified as a sensory organ.

Anyone who has practised tai chi or qigong for a number of years may have experienced this as the feeling of "qi flowing" – any sensation from a slight tingle to a deep ache – during stretching and movement. I have used these methods to tame upper-back muscle spasms, which lasted a week or two when I was in my 20s. I am now over 50 and, at worst, I am uncomfortable for a day or two after a flare-up.

I hope researchers investigate these ancient practices to evaluate their effectiveness in moving and stretching fascia tissue.

The alternative view on deforestation pledge

14 May, p 7

From Guy Cox, Sydney, Australia

You report on the fate of the Amazon, writing that "the accelerated pace of deforestation comes despite Brazil having promised to halt deforestation by 2030". Surely this is a wrong choice of words. It should read: "The accelerated pace of deforestation comes because of Brazil having promised to halt deforestation by 2030". President Jair Bolsonaro is clearly determined to clear as much forest as he can before having to honour his promise.

Designers should factor in colour of light too

16 April, p 44

From Hazel Beneke, Banksia Beach, Queensland, Australia

Your look at the psychological effects of design reminded me of an interesting experience in 1988.

The article mentioned that the level of light can affect thinking and problem-solving, but there is no mention of differences in the wavelength of lighting. At World Expo 88 in Brisbane, Australia, there was an exhibit that involved walking through a series of coloured plastic domes: green, blue, purple, red and yellow.

I wasn't surprised to find the blue lighting was the most pleasant, creating peace and calm. But the yellow caused an uncomfortable feeling, and I was beginning to feel nauseous by the time I left it.

The trouble with CRISPR cats: round two

Letters, 23 April

From Robert Willis, Nanaimo, British Columbia, Canada

I also object to the notion of using CRISPR gene editing to "make" hypoallergenic cats. Haven't we learned anything from the suffering we inflicted by breeding dogs as if they were accessories?

While I sympathise with those who have allergic symptoms wishing to cohabit with cats, one doesn't have a "right" to an animal companion. If medication and preventative caution can't alleviate symptoms – as it does with the four cats in my family – you need to find alternative pets.

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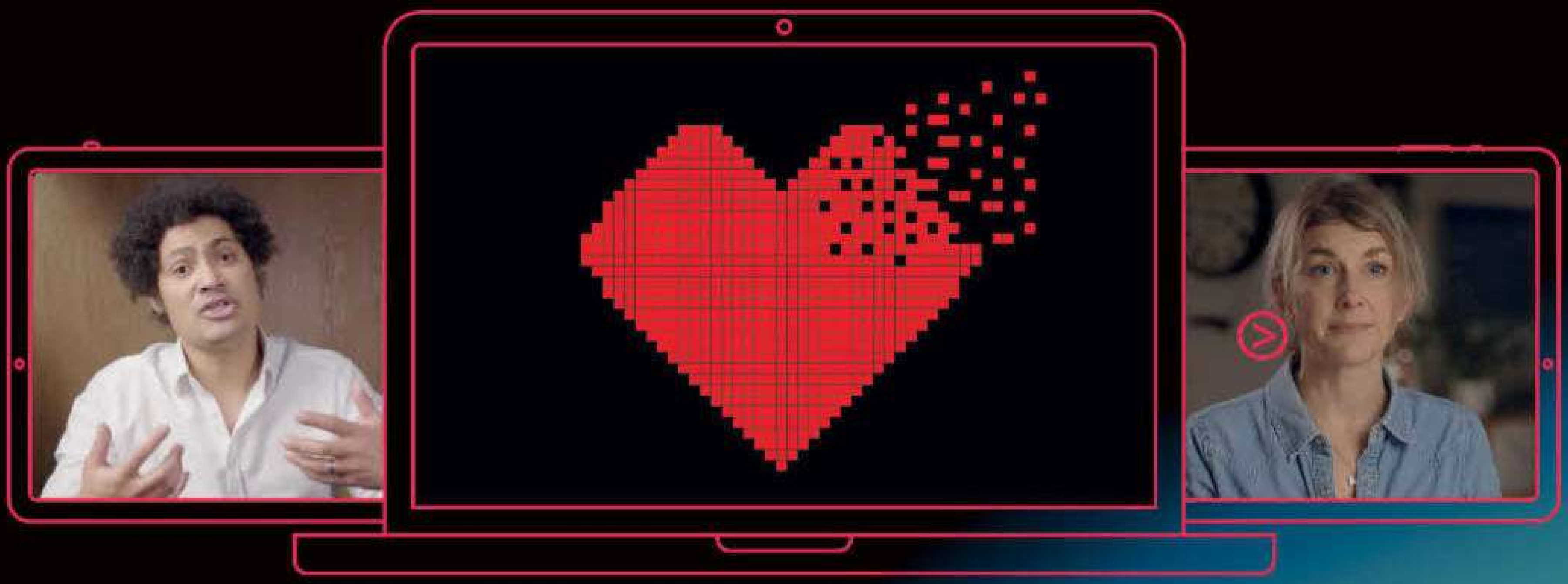

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Daleks, K9 and the TARDIS

A mind-expanding new exhibition in Liverpool, UK, sets out to explore how science has influenced the making of *Doctor Who*, discovers **Clare Wilson**

Exhibition

Doctor Who: Worlds of wonder

World Museum, Liverpool, UK
Until 30 October

IF YOU know one thing about *Doctor Who*, it may be that the TARDIS, the titular Doctor's spaceship, is based on a physical impossibility: it is "bigger on the inside". Externally, it looks like a small, blue telephone box, but those who enter find themselves in a multi-dimensional labyrinth.

While such a premise might seem fantastical, in fact, many of the ideas from the nearly 60-year-old show – the longest-running sci-fi series in the world – have been drawn from science, from the TARDIS's ability to travel through space and time, to the Doctor's capacity to regenerate and all the weird and wonderful alien life forms across the cosmos.

Exploring how science has influenced the cult TV series is the premise behind a new exhibition at the World Museum in Liverpool, UK. It is a fun and mind-expanding experience, teaching visitors about science and technology alongside some of the strange props, costumes and characters from the show.

The exhibition is cleverly designed so that as you walk around, you almost feel you could be in the TARDIS, or perhaps somehow trapped within an episode of the TV series. You enter through a simulacrum of the TARDIS's famous blue doors and are confronted with the spaceship's hexagonal control panel, albeit a simplified version of it, as it is a replica of the one from *Doctor Who*'s first series, made in 1963. Your journey continues through rooms with dim lighting, unexpected turns and sometimes monsters around a corner.

It is a thrill to meet the original Face of Boe, an immensely aged being who has ended up as a huge, disembodied head, living in a jar and communicating telepathically. Next to him is Lady Cassandra, a human from 5 billion years in the future, who is so vain and has had so much cosmetic surgery she is now just a face embedded in a single layer of skin stretched taut in a frame.

Characters such as these allow the exhibition to explore ideas about lifespan extension, including potential anti-ageing treatments, like immune system manipulation and removal of worn-out cells from our bodies. It also explores some of the practical and ethical issues we will face if we succeed in lengthening our lifespans. Now Lady Cassandra has been reduced to little more than a "bitchy trampoline", she has lost sight of all that once made her human, says Steven Swaby, the exhibition's creator.

> **"It is a thrill to meet the original Face of Boe, an immensely aged being who has ended up as a disembodied head"**

There are old friends and enemies as well as new. You can turn yourself into a Dalek by climbing inside one of their casements and waggling their notorious "sink plunger" arms. You also learn how the Daleks' famous harsh voices are created – and you can try it out on your own voice.

The presence of K9, the Doctor's old robot dog, as well as several incarnations of the Cybermen and other android-like creatures, allows the exhibition to explore our ambivalent relationship with robots. Anyone who dismisses the potential dangers of AI must never have watched the 2017 *Doctor Who* episode "Smile", represented here by one of their Emojibot killers. In this storyline, swarms of intelligent nanobots created to keep humankind happy end up murdering people who display visible unhappiness.

The nanobots, called the Vardy, were named after Canadian scientist Andrew Vardy, who studies swarm robotics and biologically inspired robots. The exhibition doesn't reveal how Vardy feels about this honour.

Another of the Doctor's most famous features is their ability to regenerate. When the show's producers decided to introduce Jodie Whittaker as the first female Doctor in 2017, it caused controversy among some fans. But as the exhibition explains, some real-life animal species, such as clownfish, display such sequential hermaphroditism, the ability for one individual to change sex within their lifetime.

If I have one complaint, it is that, at times, I would have enjoyed more in-depth explanations of some of the scientific ideas; this exhibition leans more towards entertainment than education. On the train home, I found myself rereading an old *New Scientist* article on treatments targeting worn-out cells to remind myself of the details.

If the exhibition's aim is to inspire people to learn more about science, then it worked on me. ▮

The science behind the Face of Boe (bottom left) is explored at Doctor Who: Worlds of wonder

SARNER INTERNATIONAL COURTESY OF NATIONAL MUSEUMS LIVERPOOL

Rites of passage

From animal death rites to gang initiations, rituals are found everywhere. This riveting book explores why, finds **Simon Ings**

Book

Ritual

Dimitris Xygalatas

Profile

CYLONPHOTO/GETTY IMAGES

This fire ritual in Bulgaria involves a barefoot dance on smouldering embers

"I always feel my stomach churn when I look at someone being impaled by a spear through the cheeks," writes Dimitris Xygalatas, an anthropologist at the University of Connecticut specialising in the study of extreme rituals. The version of the Thaipusam Kavadi ritual found in Mauritius is his favourite – if that is quite the word. Devotees endure many piercings, from a few needles through their cheeks to several hundred spikes perforating their entire body, "as well as hooks from which they hang bells or limes".

It is an intricate affair, but by no means exceptional. From the hazing ordeals of US fraternities to the initiations practised by criminal gangs and military groups around the world, ritual is everywhere. "If you can find a human society without any rituals," writes Xygalatas, "I will happily reimburse you the cost of this book."

Why rituals exist is a puzzle. Ask a person from Bulgaria or Spain why they walk over burning coals each year, and they are likely to shrug and say that they are doing as their ancestors did. Further explanations are more subtle, but no more revealing. The Thaipusam Kavadi ritual is said to commemorate the god Murugan receiving his spear from his mother, enabling him to lead an army against the demons.

But what if those stories were explanations after the event – genuine attempts to rationalise behaviours more ancient than any tale, more ancient, indeed, than reason itself?

Not every ritual performer in this book is human. Magpies, crows and ravens perform death rites. Chimpanzees build cairns and visit what we might dare to call sacred trees; at any rate, these regular tree visits are an occasion for dancing and feverish excitement. The pattern isn't hard to spot: the more social a species is, the more ritualistic it is.

Supposing that ritual behaviour evolved very early, especially in avian and mammalian lines, it shouldn't be too hard to figure out how this adaptation is advantageous. Perhaps ritual is the primary mechanism by which we develop theory of mind and establish group identity. More specifically, social beings become anxious in the absence of their fellows, and grief, though maladaptive, is a special form of anxiety that binds social groups together. That being the case, death rituals might exist to ameliorate the anxiety triggered by bereavement.

Xygalatas has spent 20 years fleshing out these ideas, and in that time it has become a hybrid field. Biometric sensors and hormonal sampling are used to explore the neurophysiological effects of various rituals, while more traditional ethnographic methods, including psychometric tests and surveys, reveal some of the motivations behind ritual practices.

The results aren't altogether convincing. The work is solid enough, but Xygalatas frames his conclusions in terms of how healthy ritual practices can be. Evidence suggests that physical exercise can be as effective as antidepressant medication – or would be, if conditions like depression didn't often make motivation difficult. "Cultural rituals may help circumvent this problem by exerting external pressure to participate," says Xygalatas. To me, this doesn't feel like a compelling reason to go walking over hot coals.

Xygalatas can't be blamed for wanting to put a positive spin on this fascinating and rapidly developing field of study. But even as I was reading this book, news came that Russian children were dressing up as tanks and missiles in time for Russia's 8 May Victory Day parade. This engrossing account begs a sequel, about how ritual so often proves dysfunctional among hypersocial *Homo sapiens*. ■

Simon Ings is a writer based in London

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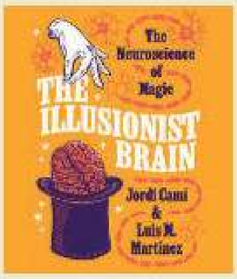
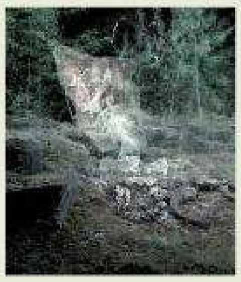
Watch

Jurassic World Dominion brings the franchise's biggest stars together for a climactic encounter between the present day and the prehistoric past. Where will humans end up in the food chain? See it in cinemas from 10 June.



Read

The Illusionist Brain is unpicked by Jordi Camí and Luis Martínez. They reveal how magicians sew illusions into our supposedly continuous experience by exploiting our foibles and fragile memories. Available to buy from 7 June.



Visit

If the Swamp at the Kistefos Museum near Oslo, Norway, is an immersive installation by French artist Pierre Huyghe. He has used autonomous software to make a digital copy of a real island, then warp it in strange ways. Open from 12 June.

AMBLIN ENTERTAINMENT/UNIVERSAL PICTURES; PIERRE HUYGHE

On the right track

The physics in this meandering but compelling novel adds flavour rather than substance, with the focus more on mental health, finds **Anna Demming**

Book

The Red Arrow

William Brewer

John Murray

SEPHIROT17/GETTY IMAGES

***The Red Arrow* takes place on a train – with the odd metaphysical detour**

DAYDREAMERS often love train journeys. When it comes to navigating a maze of fancy and reflection while hurtling at high speed from A to B, few do it with such deft eloquence as William Brewer's introspective protagonist in *The Red Arrow*.

The novel is named after the train Frecciarossa, on which the protagonist is travelling for the whole course of the novel, although most of the time his mind is elsewhere. His mission is to find the "Physicist" because he owes him a story: he is halfway through ghostwriting the Physicist's memoirs, a commission that will relieve him of a significant debt.

The nameless Physicist bears many parallels with the theorist Carlo Rovelli, who also works on theories of quantum gravity, one of the grand but vague and hypothetical ideas that the storyline hangs from. While some passages are rich in physics references – "the water around me exploded in fractals, in quantized sparkle" – the physics in the novel is more of a relish, adding flavour rather than substance. In terms of detailed science, *The Red Arrow* is more about mental health.

The protagonist has a history of suicidal depression, which Brewer relates vividly, investing readers in his character's plight and running through a whole gamut of emotional responses to mental illness, from the greater closeness he has with his partner after he confides in her, to "snap out of it" and "buck up".

For all it is a close-up look at depression, *The Red Arrow* isn't a cheerless read, and the protagonist does find a treatment that helps him. The narrator finds salvation in taking the psychedelic chemical psilocybin, a drug that is currently attracting a lot of research as a potential treatment for a range of mental health issues (see page 46).

For those with no vested interest in theoretical physics or mental health, the language throughout *The Red Arrow* is a delight. The protagonist didn't just chat about past experiences with the woman of his dreams on their first date, they "shuffled through our decks of personal history".

Brewer makes a craft of braiding his storylines, which helps prevent his many tangential musings – and they are legion – from drifting into tedium. Describing the landscape on his honeymoon as "sepia" at one point, the protagonist digresses into a comparison with "the burnished hue that lights the opening scene of *The Godfather: Part II*", from which point he starts recalling the Christmas when he first watched it, then begins to reflect on the views his father voiced on the film and what they meant for their relationship.

With a pacier plot, such detours might be more annoying, but for all its crescendo to a big reveal at the end, *The Red Arrow* is mostly about the side alleys on the way. Despite meandering at a profoundly pedestrian pace, it is a surprisingly compelling read. ▮

Meet the dinosaurs of south London

Book

The Art and Science of the Crystal Palace Dinosaurs

Mark Witton and Ellinor Michel

The Crowood Press

THE Great Exhibition of 1851 was a huge success – so huge that in 1852 the iron and glass structure that had contained it was reassembled on parkland in Penge in south London, forming the nucleus of a permanent complex of gardens, fountains and unusual attractions. The Geological Court, arguably its most beguiling exhibit, still enchants and inspires today.

Cleverly designed to evoke lost landscapes and peppered with sculptures of long-extinct creatures, this naturalistic celebration of geology and palaeontology opened in 1854. Teams of experts were involved, led by natural history artist Benjamin Waterhouse Hawkins, geologist David Thomas Ansted and mining engineer James Campbell. Theirs was the world's first attempt to depict prehistory at scale in sculptural form.

Today, enormous sloths, dainty pterosaurs and mighty marine reptiles still eye each other warily across the banks of artificial islands. Delicate and weathered, they are also oddly modern. The whole concept of a dinosaur was just over a decade old when the court opened, and visitors were startled to discover that these creatures weren't the appalling dragons imagined by artists only a few years before. "It seems a very model of innocence and contentment," wrote one journalist about the iguanodon.

In *The Art and Science of the Crystal Palace Dinosaurs*, palaeoartist Mark Witton and evolutionary biologist Ellinor Michel have assembled an indispensable work of scholarship that is also a rich visual resource. Given the fragility of the site, a record this detailed – and so charming – is long overdue. ▮

Simon Ings

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CAN FASHION REALLY GO GREEN?

Our love of cheap and cheerful clothes is hugely damaging to the environment. What does more sustainable fashion look like, and what will it take to buck the trend, asks **Graham Lawton**

A FRIEND of mine runs a vintage clothes shop in north London. Every few weeks, she visits a vast warehouse on the edge of the city to rummage through piles of discarded clothing. Most of it is worthless, but if you know what you are looking for, there are diamonds in the rough.

The warehouse has a long history. It was once a clearing house for the low-quality wool scraps called shoddy that were used to make cheap clothing for the masses in Victorian Britain. A century on, little has changed. Nowadays, it is full of modern-day shoddy: low-quality cotton, polyester, viscose and nylon, all in the form of cheap clothing made for the masses around the world. Except that this stuff is going to landfill and incinerators, not being reused.

The items are the products of an industry that, in the past 30 years, has become one of the most successful and also most destructive on the planet. Known as fast fashion, it has filled our wardrobes with cheap and cheerful clothes. But after three decades of remorseless growth, the model is butting up against fundamental environmental limits and there is widespread agreement – even from within the industry – that it is time to hit the brakes.

"The fashion industry represents a key environmental threat," says Kirsi Niinimäki at Aalto University in Espoo, Finland. "Ultimately, the long-term stability of the fashion industry relies on the total abandonment of the fast-fashion model."

Like fast food, fast fashion is all about instant gratification on the cheap. The term came into

KASIQ

widespread use in 1989 after *The New York Times* reported that a new Zara outlet could have a novel item of clothing in store just 15 days after it was a twinkle in a designer's eye. In those days, fashion houses typically created two new collections a year. Now, the fastest can rack up two a month.

> "THE FASHION INDUSTRY HAS BECOME A THREAT TO THE HABITABILITY OF THE PLANET"

This business model feeds off impulse purchases of low-priced, low-quality clothes, driven by endless novelty, says Niinimäki. Over recent decades, this pattern of consumption has become the norm for most people in the West and is spreading around the world, says Patrizia Gazzola at the University of Insubria in Varese, Italy.

Its temptations have lured consumers into buying more clothes than they need or even want, while simultaneously wearing them less and discarding them sooner. It isn't hard to find shocking statistics about this. Fashion bible *Vogue* reports that of 100 billion items produced yearly, three in five will be discarded within the year. According to a recent paper by Niinimäki, the average US consumer buys 66 items of clothing each year – one every 5.5 days – and discards them at roughly the same rate. Other research by the Stockholm Resilience Centre in Sweden says most clothes are disposed of within three years.

This isn't just a Western trend; according to fashion technologist Shanthi Radhakrishnan at Kumaraguru College of Technology in Coimbatore, India, the number of times a garment is worn has fallen by a third globally in the past 15 years.

From a business perspective, this model has been "hugely successful", says Niinimäki. But from an environmental one, it is an abject failure. Last year, the Stockholm Resilience Centre, which developed the concept of planetary boundaries for vital life-support systems on Earth, published a study warning that the fashion industry is now so damaging that it has become a threat to the habitability of the planet.

Fast fashion has vastly inflated the industry's size and output. Between 1975 and 2018, global per-capita textile production rose from 6 kilograms to 13 kilograms a year, with most of the increase in the form of polyester for clothing. According to the UN Alliance for Sustainable Fashion, global clothing production doubled between 2000

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and 2014. The world currently buys 62 million tonnes of apparel per year – some 100 billion items of clothing.

Even the fastest of fashionistas can't keep up. By some estimates, about a third of clothes imported into the European Union are never sold and end up growing old and frumpy in warehouses, or are simply dumped. "Right now, garment workers, as well as being underpaid and overexploited, are also producing an inefficient and downright bonkers amount of clothing," says Orsola De Castro, co-founder of the activist group Fashion Revolution.

The fashion industry has been slow to embrace sustainability, says Andreza de Aguiar Hugo at the Federal University of Itajubá in Brazil. "For the most part, the fashion industry still operates using a linear model of extracting, producing and disposing of resources," she says. However, the industry knows it can't continue like this, especially as consumers wise up to the environmental cost of their shopping habits. "We are keenly aware of the current climate, environmentally [speaking]," says Jaki Love, director of innovation and sustainability at UKFT (the UK Fashion and Textile Association). "The linear, take-make-dispose model is unsustainable. A circular model is the only way forward."

Unsurprisingly, this juggernaut of production and consumption has a huge environmental footprint. Establishing just how big, however, is difficult. Fashion is routinely described as the world's second most polluting industry, although the source of this "fact" is invariably a media report making the same unsubstantiated claim. Even the UN Alliance for Sustainable Fashion repeats it, but with the caveat that this is "widely believed".

When science-based sustainable fashion website Ecocult tried to establish where the statistic originated, it discovered a tangle of different numbers from various non-peer-reviewed sources. The problem is that fashion intersects with so many other polluting industries, including fossil fuels, petrochemicals, manufacturing, agriculture, logistics, retail and construction, that teasing out its individual environmental footprint is difficult.

The most authoritative number Ecocult found comes from a report by the World Economic Forum (WEF) and Boston Consulting Group on how the dirtiest industries can clean up their supply chains. It concludes that fashion is responsible for 5 per cent of global greenhouse gas emissions, making it the third most climate-damaging industry on Earth, after food (25 per cent) and construction (10 per cent) and ahead of cars, electronics and the freight industry.

Fashion's environmental destructiveness extends beyond greenhouse gases (see "The journey of your jeans", opposite). According to de Aguiar Hugo, it consumes about 100 million tonnes of non-renewable resources every year, including oil to make synthetic fibres and dyes, and chemicals to colour and finish the fabrics. It also swallows 93 trillion litres of water a year.

OUT OF FASHION

At the other end of the fashion pipeline, effluent gushes out. Textile waste is the main problem, with more than 90 million tonnes of worn out, unwanted or unsold clothes being discarded every year. On top of that, more than a tenth of the fabric sent to garment factories ends up as off-cuts. Globally, less than 20 per cent of this waste is recycled; the rest ends up in landfill, incinerators or the environment. The Stockholm Resilience Centre says that 85 per cent of litter on beaches is textile waste. "Every second, the equivalent of a garbage truck of textiles is burned or landfilled," says Tatiana Valovaya, director-general of the United Nations Office in Geneva, Switzerland.

That isn't the end of it. About 20 per cent of the world's industrial waste water is created by treating and dyeing textiles, and textile production also dumps 190,000 tonnes of microplastic pollution into the ocean each year, which is about a third of the total. Yet more microplastics are generated by laundering and drying clothing, and when discarded items degrade. According to the UN, a total of half a million tonnes of textile-derived microplastics find their way into the seas every year.

Caring for clothes also consumes vast quantities of water, energy and detergents. A report by the European Commission's Joint Research Centre found that this "consumer use" phase of the clothing life cycle is the most environmentally damaging of all, especially if clothes are tumble-dried and ironed (See "Tips for a greener wardrobe", p44) .

All told, "the fashion industry is responsible for one of the most glaring environmental failures of our current economic system", says Valovaya.

And it is forecast to carry on failing.

Designer brand Ganni offers a facility to resell preloved items like these calf leather loafers

GANNI

According to Elisa Tonda, head of the Consumption and Production Unit at the UN Environment Programme (UNEP), the greenhouse gas emissions from the industry are expected to rise by almost 50 per cent by 2030. Global fibre production is expected to rise at about the same rate, exceeding 150 million tonnes by 2030. Unchecked, the fashion industry alone will produce a quarter of the carbon dioxide we can afford to emit by 2050 if we are to have a chance of staying below 2°C of warming. Definitely not cool.

"The industry is realising that a transformation is needed," says fashion specialist Sebastian Boger at Boston Consulting Group in Munich, Germany. But as yet, he says, its pledges and actions fall short of what is needed.

What is required, says Niinimäki, is nothing less than a complete makeover, from raw material production through to consumer behaviour, to destroy the fast-fashion model and shrink the industry. That, however, won't come easy to an industry and its eager customers that she says are mutually hooked on ever-increasing production and consumption.

Just tackling the greenhouse gas part of the problem will require an enormous effort. According to the WEF report, even

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> "THE INDUSTRY NEEDS A COMPLETE MAKEOVER, TRANSFORMATION IS NEEDED"

THE JOURNEY OF YOUR JEANS

To understand where the environmental impacts of clothing come from, consider the cradle-to-grave life of a pair of jeans.

The starting point is a cotton field somewhere in Asia, probably India or China. A cotton crop takes about 160 days to grow, sluiced with water and chemicals, after which the fibre is harvested and separated from the rest of the plant. The raw cotton is sent to a factory to be washed, bleached, dyed and spun into yarn. At this point, small amounts of the synthetic fibre elastane – also called spandex or Lycra – may be added, which adds a pleasing stretchiness, but can rebound when it comes to disposal, as it makes the fabric very hard to recycle. The yarn then moves on to a textile factory to be woven into denim, from where it goes to yet another factory to be cut and sewn. Buttons, zips, linings, labels and patches – usually manufactured elsewhere – are added here.

Most of these production processes are labour and resource-intensive and happen in places where wages and environmental standards are low, often south and South-East Asia. According to Kirsi Niinimäki at Aalto University in Espoo, Finland, it isn't unusual for each step of the manufacturing process to occur in a different country.

Once finished, the jeans embark on the second phase of their life cycle. They are shipped in large quantities to distribution centres in North America and western Europe, where consumer demand tends to be highest. Clothes usually travel by boat, but air freight is increasingly common, says Niinimäki, as the fast fashion cycle accelerates. This distribution phase also generates waste in the form of packaging, tags and hangers.

From the distribution centres, the jeans are dispatched to physical or online retailers and some of them are bought by consumers, worn, washed a few times (see graphic), then ditched. Some go straight into the bin; others are put in recycling banks.

Regardless of where and how consumers dispose of them, discarded clothes generally end up in one of two places: landfill or incinerators. Some are shipped to developing countries, mostly in Africa, to be patched up and resold or dumped all over again. Only about 20 per cent are recycled in the country where they were worn, largely for one-time "downcycled" applications such as cleaning cloths and insulation materials, which also eventually end up in landfill or incinerators. Just 1 per cent of the textiles from discarded clothing are re-spun into new fibres for clothes.

Every step of this long and convoluted journey – a garment and its components can travel the equivalent of several times around the world before being put on sale – has environmental impacts, guzzling energy, water, oil and synthetic chemicals, and disgorging all kinds of waste.

According to a report by environmental research group Mistra, the production, consumption and disposal of a single pair of jeans manufactured in Asia and bought in Sweden emits the equivalent of 11.5 kilograms of carbon dioxide – about the same as driving a car 60 kilometres. And that doesn't take into account the impact of laundering, which can be the main contributor to the carbon footprint of clothing. According to the United Nations Alliance for Sustainable Fashion, the process also consumes around 7500 litres of water, the amount an average person drinks in seven years.

DIGIPUB/GETTY IMAGES

MARCIN ROGOZINSKI/ALAMY

Only a tiny proportion of discarded clothes are ever recycled

if manufacturers do everything in their power – upgrade to energy efficient machinery and transport, install renewable sources of heat, use greener dyeing and other processing technologies and choose recycled fibres and textiles – that will only eliminate about 50 per cent of emissions.

The other half of the industry's emissions remain in the gift of somebody else. The biggest win – a more than 40 per cent reduction – would be for the producing countries to phase out fossil fuels for generating electricity, although this ignores the fact that many garment factories in Asia aren't hooked up to the national grid, but use their own coal-powered generators, says Boger. A further 10 per cent can be squeezed out by growing cotton more sustainably.

That pessimistic analysis, however, rests on two assumptions: first, that the industry will continue to weave away at its current rates, and second, that technology will essentially stand still. Neither is necessarily true.

Recycling technology in particular has much room for improvement. The WEF calculates that recycling will shave only a measly 2 per cent off emissions, but this reflects the fact that current methods are pretty threadbare.

At present, there are two basic recycling processes for textiles: mechanical and chemical. Mechanical is applied mainly to natural fibres such as cotton and wool, which are shredded and carded, or combed, to recreate fibres that are spun into new yarns. The problem is that the process degrades the fibres significantly. "With mechanical recycling technologies, you are weakening the properties of the fibre – you're shortening the fibre, which means that you are getting worse quality," says Petri Alava, CEO of textile recycling firm the Infinited Fiber Company in Finland. Recycled cotton must contain up to 50 per cent virgin cotton to make it viable, he says (See "The worst materials", opposite).

Then there is chemical recycling, which takes polymers, breaks them down into their constituent monomers and rebuilds them. This is doable for cotton, viscose and polyester, but the technologies are in their infancy and need to be improved, says Niinimäki. Recycled polyester is an increasingly common material and is often trumpeted as "sustainable" by retailers, but the vast majority is recycled from plastic bottles made of PET, a type of polyester, rather than clothing, says Niinimäki. "It's not made from polyester garments because there are some technical problems existing for recycling that type of polyester."

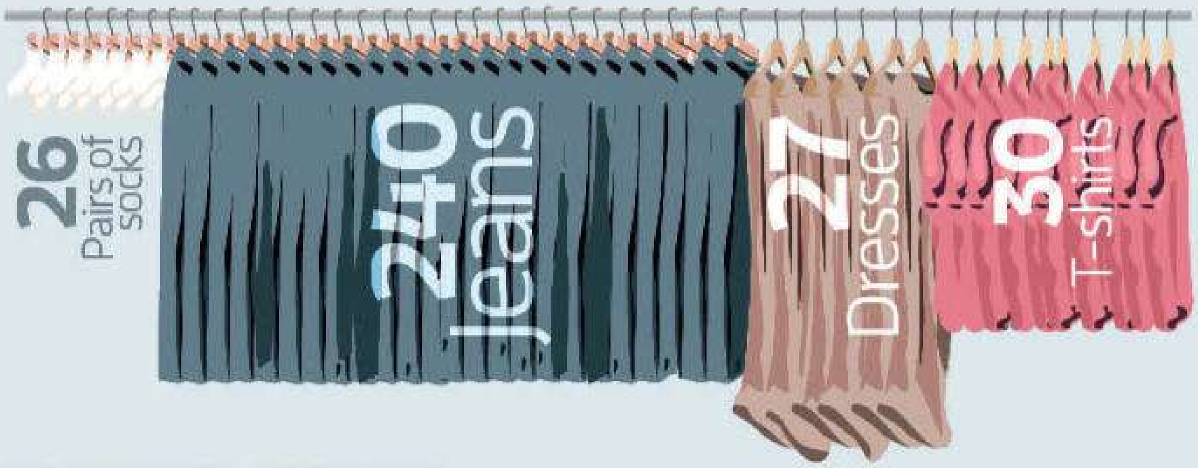
Mixed fibres such as cotton-polyester blends present a major challenge. Elastane is also a stretch. "Elastane is a very nice material because it gives the flexibility to clothing, but it is very nasty for recycling," says Alavi.

RECYCLING INCENTIVES

Even before new recycling techniques can be brought to bear on textile waste, there are mountains to climb. Some retailers have started collecting old clothes, rewarding customers with vouchers or other incentives to recycle old garments (and ultimately to buy new ones). But clothing waste arrives at

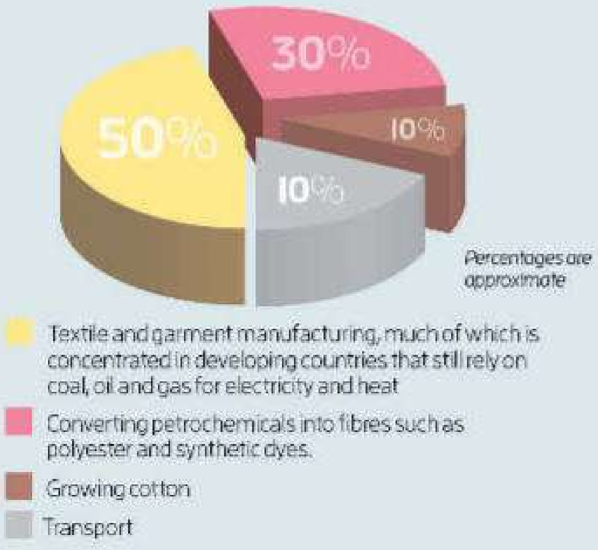
SOME GARMENTS ARE WORN MORE THAN OTHERS

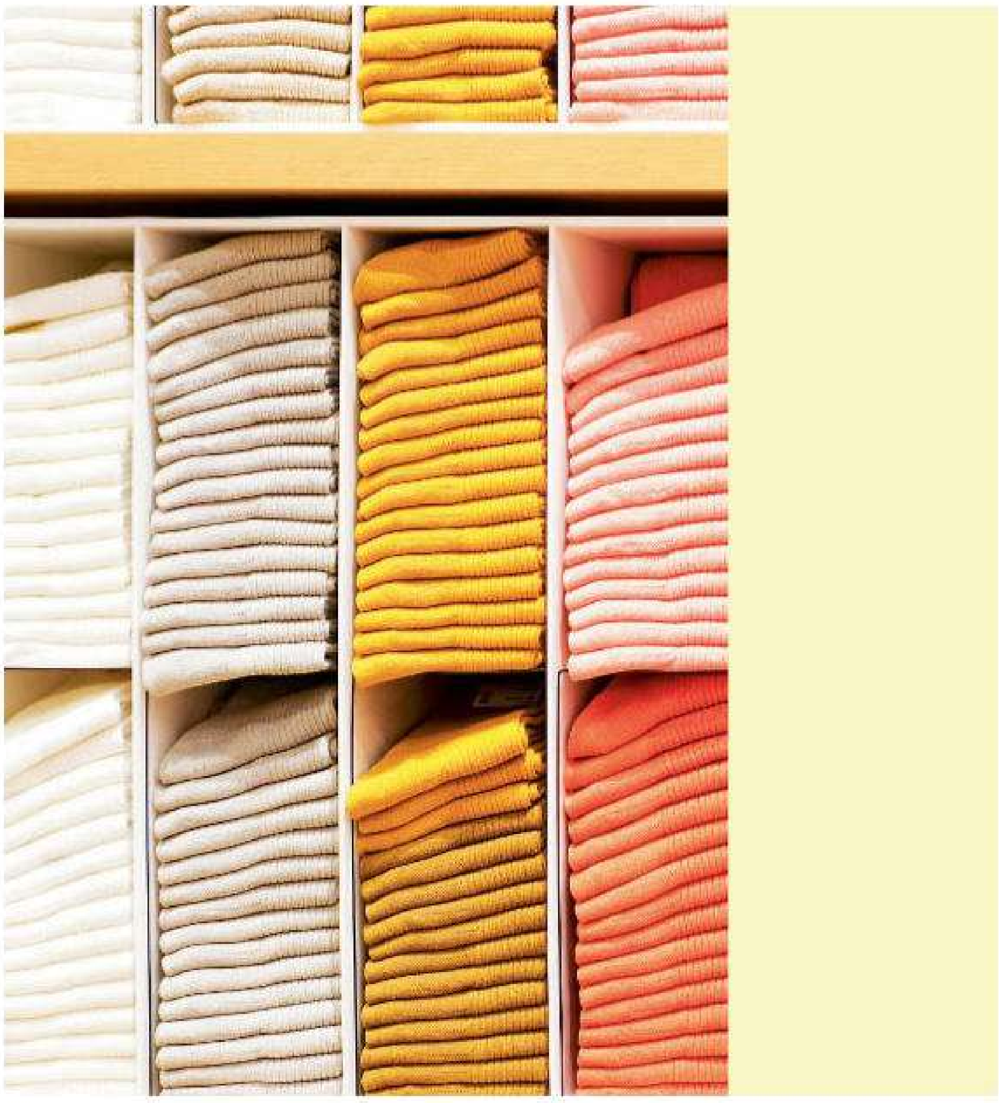
Estimates of the number of times we wear each item



SOURCE: SWEDISH FOUNDATION FOR STRATEGIC ENVIRONMENTAL RESEARCH (MISTRA)

WHERE DO FASHION'S CARBON EMISSIONS COME FROM?





Colourful, yes, but dyes add to fashion's environmental impact

JACKYENJOYPHOTOGRAPHY/GETTY IMAGES

recycling centres as a jumble that has to be sorted by hand – although automated systems are in development. Trims, such as zips, buttons and patches, must be removed and often can't be recycled. No wonder that only 1 per cent of the world's textile waste is turned back into clothing.

The process needs to change, says Niinimäki, and that is starting to happen. Infinited Fiber is one of the companies leading the charge. Using a process developed at VTT Technical Research Centre of Finland, it takes cellulose-rich waste such as cotton and cardboard, cleans it up, breaks it down into its molecular units and re-polymerises it into a new fibre called Infinna. This is a synthetic fibre similar to viscose, but without the need for virgin wood pulp and harsh chemical processes. The cycle can be repeated endlessly, each time generating new fibres, so there is none of the decline of quality seen with mechanical recycling, says Alava. The technology can also be retrofitted into existing viscose factories and the chemicals recycled to cut waste to a bare minimum.

> "PILES OF DISCARDED RAGS COULD BE TRANSFORMED INTO PRISTINE WHITE YARN"

Infinited Fiber is in the pilot stage, but is planning a large factory with an annual capacity of 30,000 tonnes, due to open in 2024. It envisages piles of discarded rags arriving on pallets, being sorted and processed and leaving as bundles of pristine white yarn for use by its customers, which already include big clothing brands H&M and Patagonia.

Several other companies are working on similar technologies, including Renewcell of Sweden, which makes a cellulosic fibre called Circulose. "There's a lot happening, but Infinited Fiber is the most advanced, they are really close to commercialising this technology," says Niinimäki.

Another company trying to break the linear model is Teemill, based in the UK. It makes garments from pure cotton and natural dyes using 100 per cent renewable energy. It holds a stock of basic garments, but only dyes and finishes them once somebody has ordered, which eliminates much of the waste of fast fashion. Crucially, every item of clothing has a label with a QR code, which can be scanned ›

THE WORST MATERIALS

Cotton accounts for about 25 per cent of global fibre production, and is widely regarded as the most environmentally damaging raw material for making clothes, largely due to the cotton plant's thirst for water and use of fertilisers and pesticides. But the alternatives are scarcely better. Polyester, which overtook cotton production in the 1990s and now accounts for about half of global fibre production, is made from petroleum and is non-biodegradable. It is hard to recycle and releases microplastics when laundered. By weight of fabric, its energy consumption and carbon footprint are greater than that of cotton. Synthetic polyamides such as nylon are even worse.

Half-synthetic textiles such as rayon and viscose – which are made from wood pulp and other plant material in chemical factories – are theoretically better because they can be produced from renewable resources. Yet manufacturers are often criticised for using unsustainable wood and manufacturing processes that rely on non-recyclable polluting chemicals. What's more, even though the cellulosic fibres created are biodegradable, they emit methane in landfill. The overall environmental footprint of these synthetic cellulosic fibres is only slightly smaller than polyester's.

Fully natural fibres aren't a good alternative. Wool has a huge carbon footprint because it comes from sheep and other methane-belching ruminants. Silk, which requires large amounts of energy to grow and maintain mulberry trees in which silk worms thrive, is the worst of the lot.

TIPS FOR A GREENER WARDROBE

If your wardrobe contains items of clothing you bought on the high street for relatively low cost, you are a participant in the fast-fashion industry. But don't feel too guilty. Everybody needs clothes and dressing sustainably can be complicated. With a little know-how, however, there are things we can all do to look good without the environmental price tag.

The first step is to think long term, says Kirsi Niinimäki at Aalto University in Espoo, Finland: "Short use-time of garments is really harmful for the environment."

She suggests you start by liking what you have. Go through your wardrobe and dig out any long forgotten garments that you can start to use again.

If you want a change of look, or need a particular item, consider using flea markets, buying second-hand or holding clothes swapping events with friends. Apps and websites that allow you to lease clothes from others, and get more use out of your own pre-loved items by renting them out, are increasingly common. Some fashion labels are also working with the makers of the apps, so you can rent clothes directly from them, with the quality control that comes with it.

Shopping for new clothes requires a shift of mindset away from the budget-friendly lure of fast fashion. "If buying something new, see garments as an investment," says Niinimäki . "Think about the quality and if the style is something we can use for a longer time." Many companies offer a repair service. "As consumers, I think that we can educate ourselves a bit more about garments and the fibres that they are made of," she says.

Once an item is in your wardrobe, how you look after it can make a difference. "There's the old adage, buy better, buy less," says Jaki Love, director of innovation and sustainability at UKFT (the UK Fashion and Textile Association). "But the majority of negative impacts from fashion actually occur post-sale, and so consumers have it within their gift to reduce this impact through how they launder."

So, wash clothing sparingly, avoid tumble-drying and iron only when necessary, to reduce the amounts of water, energy and detergent involved.

"And when it comes to disposal, if a garment is in a condition that somebody else can wear it, return it to the market. If it's really like a waste, find a place that accepts the textile waste."

It is also important to question any claims you read on labels or in shops, which can be misleading. A recent report by the Changing Markets Foundation in the Netherlands found that certification programmes designed to clean up the fashion industry can backfire, leading to greater consumption, pollution and use of fossil fuels.

There are some handy resources to help you cut through the hype. The Fashion Transparency Index ranks 250 of the world's largest fashion brands and retailers according to what information they disclose about their environmental and social policies. You can also check a clothing brand's green, social and animal welfare credentials at the Good On You directory. Ultimately, when you buy something new you need to ask yourself three questions, says Mart Drake-Knight, founder of sustainable clothing brand Teemill in the UK. "Who made it? What is it made from? And where will it end up when I am done with it?"

OREOLIFE/ALAMY

We can all take steps to cut the environmental impact of our clothing

at the end of its life to get instructions on how to return the item to Teemill for recycling, in return for a discount on the next order. Eventually, Teemill hopes that there will be enough discarded cotton coming in to meet the demand for new clothes. "The material stays in use and doesn't enter landfill. It just flows round in a circle – out to the customer, back to the business, out again to the customer," says Teemill founder Mart Drake-Knight. "We see the customers as custodians of the material." Teemill, which gets 5 out of 5 on the ethical and green fashion rating website Good On You, also makes its software and manufacturing facilities available for free so budding designers can start their own brands and together build a new circular clothing economy. "We could wait for all of the big brands to change," says Drake-Knight. "Or co-create an alternative future where they get replaced."

"CONSUMERS MUST BE PREPARED TO PAY HIGHER PRICES"

The goal of all these companies is to "close the loop" – that is, to create a circular economy in textiles where today's waste products are the feedstocks for tomorrow's clothing and so on in an endless cycle. As well as stemming the industry's waste stream, this would go a long way to reducing the pressures of generating virgin materials such as cotton, wood pulp, polyester and wool.

We aren't there yet, though, says Niinimäki, and there may be some loopholes that cannot be closed. Some mixed fibres may prove impossible to recycle and may have to be phased out, possibly including the cotton-polyester blends that make up a significant proportion of fast fashion items. At present, the cotton can be extracted and recycled but the polyester remains stubbornly disposable. "It might be that we have to redesign our guidelines about what kind of fibres we can use in the textile for fashion so that they are easier to recycle at the end of their life," says Niinimäki.

Polyester may have to be sacrificed altogether, although that would be a shame, she says. "It's a good fibre, especially in sport clothes because of its functionality. It's not easy to

substitute." Ditto elastane, although there are emerging alternatives. And some virgin materials will still have to be produced to fulfil demand, she says.

In the EU at least, there isn't much time to solve these problems. The bloc has set itself a target of 2025 for all textile waste to be collected for reuse rather than landfilled or incinerated, and for an effective recycling system to be in place. That is sending clear signals to the industry that it is time to switch to a circular model, says Niinimäki, but their level of preparedness is debatable. "Companies are quite aware that there will be a change, but they are a little bit lost, they don't know how to do that change."

And closing the textile loop only solves part of the problem. As the WEF report makes clear, the textile and garment manufacturing industry in Asia is where most of the industry's environmental impacts come from. That could be mitigated by cleaner and more energy efficient processes and decarbonisation of the host countries' energy supplies, but a more immediate lever is to be found closer to home: us. "Consumers must be ready to pay higher prices," says Niinimäki.

There are signs that people are becoming more aware of the negative environmental and social impacts of fast fashion and are looking for alternatives. "Consumers are saying that the supply chain should be much more transparent so that we actually know exactly where these garments are made in what kind of conditions," says Niinimäki. "This seems to be more and more important as background information for the purchase decision."

Getting that information, however, isn't straightforward. Clothing labels are fairly uninformative beyond saying where and of what the garment was made, and how to care for it. Where the textile came from and what to do with it at the end of its life don't feature. But that probably doesn't hide very much. If it was cheap and bought in a high-street store, then chances are it is fast fashion.

Retailers are also responsive to consumer trends and increasingly offer options that sound environmentally friendly, such as lifetime guarantees, repair services and buyback schemes for unwanted items. But greenwashing is rife in this area, warns Niinimäki, especially among the big players who have the most to lose from abandoning the status quo. Even so, they also know that business-as-usual is running out of road. "The industry knows that Earth's capacity to produce raw materials and assimilate polluting emissions can become a constraint on its growth," says Tiina Häyhä at the Stockholm Resilience Centre.

SLOW FASHION

The only real way to break the cycle is for consumers to deliberately slow down. According to a recent report by the Ellen MacArthur Foundation, the single most effective way to make a difference is to increase the average number of times clothes are worn. "Lifetime is really critical here," says Niinimäki. That means not just buying fewer garments and wearing them more, but also opting for better-quality and more expensive ones, hanging on to them for longer and planning for their afterlife. Buying second-hand, repairing old clothes and embracing new models of ownership such as leasing can also help. Such a shift in consumer demand will eventually feed back to the garment industry and help to break the fast fashion model, says Niinimäki.

Whether punters will accept such radical change has yet to be properly tested. There can be no denying that fast fashion is fun, entertaining and a source of emotional fulfilment for many of us. Asking people to swap it for hair shirts is bound to fail.

But by definition, fashion is about innovation, novelty and trendsetting, and right now there is plenty of that. "I see optimistic signs," says Niinimäki. "Textile recycling, renting and leasing, repair services, quality guarantees, collecting back old garments and reselling them, redesigning new garments out of old ones – all these give a positive vibe that it is possible to make the fashion business more sustainable. Of course, there's a lot of work to do, but I'm optimistic." ▮

Graham Lawton is a feature writer for *New Scientist*

The trip treatment

Hallucinogenic substances like psilocybin can help people with serious mental health problems, but is the psychedelic experience entirely necessary? **Thomas Lewton** reports

JANELLE BARON; PEXELS/COTTONBRO

“SWITCHED OFF”, “short-circuited” and “shut down”. This is how three participants described their depression before they took part in a clinical trial for psychedelic-assisted psychotherapy at Imperial College London in 2016.

Their outlook changed dramatically after taking a high dose of psilocybin, the active ingredient in magic mushrooms. “I was a ball of energy bouncing around the planet,” one recounted in an interview with Rosalind Watts, a clinical psychologist who led the trial. Another described the experience as akin to defragging a computer hard drive: “I visualised as it was all put into order, a beautiful experience with these gold blocks going into black drawers that would illuminate.”

Such transformations are no longer surprising. Similar trials have established psychedelics as a game changer when it comes to tackling the global mental health crisis. “There’s a huge unmet need, and psychedelics do have radical potential,” says Watts.

Now, some scientists are creating new drugs that remove the psychedelic experience, or “trip”, while still offering therapeutic benefits. But Watts and others are warning that this approach misunderstands how psychedelic therapy works – and that if we try to squeeze it into a pill-popping industrial healthcare model, its vast promise may never be realised.

They aren’t just dishing out warnings, though. Some of the pioneers of the field are moving beyond the simple story that psychedelics “reset the brain” by carefully investigating the role of the psychedelic experience, and the therapy that accompanies it. The aim is to establish exactly what we can’t lose if we are to make good on the hopes raised by psychedelic medicine’s recent successes.

In psychedelic therapy, people are given a high dose of psychedelics under the careful guidance of therapists, bookended by therapy. There is no doubt that it can be an effective treatment. Over the past decade, researchers have demonstrated that it can relieve various mental illnesses in people who don’t respond to existing treatments. Small-scale clinical trials have found that one or two doses of psilocybin, for instance, can alleviate symptoms of major depressive disorder, reduce anxiety in people with cancer, enable people who are addicted to alcohol to abstain and release those with obsessive-compulsive disorder from their rigid habits. In November 2021, the biggest trial to date found that a single dose of psilocybin relieved treatment-resistant depression for three months in a quarter of patients. These people had tried at least two other treatments without success.

The results speak for themselves. But clinical trials are far from the real world of public healthcare systems. Billions of people struggle with depression, anxiety and various other mental health conditions. The big question is: if psychedelics were to become legal treatments, could you replicate this experience for everyone who wants it?

For David Olson, a chemist at the University of California, Davis, the answer is to create new drugs that offer the transformative powers of psychedelics without the experience. These

trip-free psychedelics would, he says, remove the risk of bad trips, known as "bottom-margin cases", which happen most often in people with pre-existing psychiatric conditions, such as schizophrenia and bipolar disorder, and can significantly worsen mental health. And they would also remove the requirement for lengthy and expensive therapy, making it accessible for as many people as possible, he says. "I worry that this is going to become a treatment only for the people who can afford to pay out of pocket," says Olson.

To create these "non-hallucinogenic psychoplastogens", Olson's team systematically masks different parts of the chemical structure of psychedelics to understand which bits give rise to which effects. "You can just keep the features that are beneficial and remove the features that are not," he says. One hallmark of depression, post-traumatic stress disorder and substance addiction is the wasting away of brain cells in the prefrontal cortex, the region associated with complex behaviours and higher-level thinking. Evidence suggests that psychedelics regrow and realign these brain cells, so Olson hung on to these functions while removing the parts that give the visceral experience.

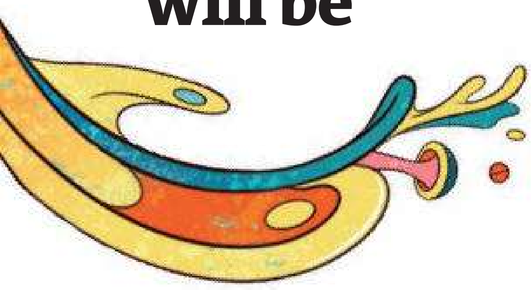
Moments of meaning

Psychoplastogens have produced promising results in mice, regrowing neurons and making their brains more malleable, while also reducing behaviours associated with addiction or depression. "It's very comparable to what you see with hallucinogenic compounds, and that gave us a hint that it might be possible to do this," says Olson, who is planning human trials later this year with Delix Therapeutics, a company he co-founded. In theory, psychoplastogens could be picked up at the pharmacy like any other prescribed pill.

But some are sceptical that trip-free psychedelics will work in humans. David Yaden, a neuroscientist at Johns Hopkins University in Maryland, agrees that low-level brain cell changes play an important role in how psychedelics work, but stresses that psychoplastogens are still hypothetical. "It's hard to infer on the basis of rodent research what will happen in human clinical trials," he says. "My strong suspicion is that the acute subjective effects will be necessary for full and enduring therapeutic impacts."

Yaden is referring to the intense personal experiences people have when they take psychedelics and the meaning that comes ›

> **"The intensity of experience predicts how successful the treatment will be"**



with them. The extent of that intensity became clear to Roland Griffiths, also at Johns Hopkins, who collaborates with Yaden, about two months after he ran his first psilocybin clinical trial, when volunteers returned to report on their progress. "It wasn't uncommon for them to say: 'That's the most meaningful experience of my life, on a par with the birth of my firstborn child'," he says. Indeed, a third of participants in that study said it was the single most spiritually significant experience of their life.

This led Griffiths to design the Mystical Experience Questionnaire (MEQ), which tries to quantify the importance of spiritual experiences during psychedelic therapy, although he is at pains to point out that the MEQ measures a "secular spirituality". Different research groups describe these kinds of experience with different metrics, but whether it is "ego dissolution", an "experience of unity" or an "emotional breakthrough", they are broadly equivalent. "These are all what I'd consider self-transcendent experiences," says Yaden. And the upshot is that the intensity of these events predicts how successful the treatment will be weeks or months later.

Griffiths suspects the experiences provide a new template for how people view themselves within the world, and so alter how they make decisions going forward. Still, he says that while subjective experiences are probably necessary for positive outcomes, the question isn't settled. The only bulletproof test, he says, is to give psychedelics to people who are under anaesthetic and so are unconscious. "Those studies are really difficult, but people are making a stab at them," he says.

In the meantime, others are working on more holistic, theoretical models of how psychedelic substances work – something that goes beyond the existing mechanistic idea of chemicals modifying brain cells. Working with Karl Friston at University College London, Robin Carhart-Harris, a neuroscientist at the

The perfect trip

Counterculture icon Timothy Leary coined the term "set and setting" in the 1960s to emphasise how someone's initial mental state, together with their physical and social environment, deeply informs their psychedelic experience. Now, while some seek to make "trip-free psychedelics" (see main story), Robin Carhart-Harris is painstakingly searching for the perfect therapeutic trip.

A neuroscientist at the University of California, San Francisco, Carhart-Harris last year opened a lab called Neuroscape to untangle which circumstances lead to the best outcomes for people undergoing psychedelic-assisted psychotherapy, and how brain-imaging technology can guide that process. There, Carhart-Harris and his colleagues can tailor the therapeutic environment during the trip itself. For example, they are testing guided meditations to prepare participants, as well as more active and engaged therapy during sessions. They are also working with musicians and film directors to create immersive audiovisuals of wild landscapes, complimented with natural scents. "The psychedelic experience is, in a sense, a return to a simpler state," says Carhart-Harris. "Just to be reminded of our essence seems to harmonise very nicely with the psychedelic experience."

Intriguingly, Carhart-Harris and his colleagues are even developing technology that could inform therapists about their patient's state of mind during a trip without having to ask. "When you're a guide in psychedelic therapy sessions, most of the time you're just guessing where someone is," he says. "Are they in a pretty good place? Or are they in a struggle state?" The therapist could intervene accordingly to create a safer, more nurturing environment for psychedelic therapy.

No one knows what the brain looks like in those struggle states, so Carhart-Harris is combining deep-learning algorithms with functional magnetic resonance imaging (fMRI) of the brain to build a picture of how subjective experiences map onto physical brainwaves. Scanning a small number of volunteers many times will allow him to create a portrait of psychedelic substates and so map which kinds of brain pattern correspond to different experiences. Similar technology has already been used to create algorithms that can accurately predict what people are dreaming about from an fMRI read-out.

Carhart-Harris hopes that figuring out the "winning formula" could also offer solutions for people with existing psychiatric conditions like schizophrenia and bipolar disorder. They are more likely to have bad trips, and are therefore generally seen as too high risk for psychedelic-assisted therapy. "We lack enough treatments for the really hard cases, so it's kind of a protective motivation," he says.

A therapy room at Neuroscape in San Francisco, California

COURTESY OF NEUROSCAPE

University of California, San Francisco, has developed a model that pieces together the many levels on which psychedelics act: from molecular interactions to large networks of brain regions to what they call the "relaxation of beliefs under psychedelics".

The idea, known as the "REBUS and the Anarchic Brain" model, is rooted in the predictive processing theory of consciousness. This posits that we make sense of the world by predicting what will happen based on past experiences and comparing it with what we actually sense. If there is a mismatch, it creates a prediction error that is used to update our prior beliefs. Together, they form our perception of the world and ourselves.

Friston and Carhart-Harris suggest that, in all this back and forth, certain prior beliefs can become entrenched in an unhealthy way, sometimes as a result of traumatic experiences. "You become an expert in whatever your pathology is: negative ruminative thinking and being stuck in your head in depression, for instance," says Carhart-Harris. "It is planted, and very resistant to treatment." What psychedelics do, according to the idea, is make the brain more sensitive to prediction errors, creating a temporary anarchy that allows you to remould your prior beliefs.

JURIS KRAULIS/ALAMY

Psilocybin, which is found in magic mushrooms, has relieved depression in clinical trials

Difficult conversations

Anarchy, though, comes with risks. After all, we may dig these mental ruts for self-protection and stability. "The outcome isn't inevitably and unconditionally always one of healing," says Carhart-Harris. "When you're opened up, you're vulnerable to the conditions that you find yourself in." Which is why Carhart-Harris and others attribute so much importance to the experience you get when you take psychedelic drugs – and the therapy too.

The reality is that the psychedelic experience is just one part of a demanding process. Participants in clinical trials spend many hours with at least one therapist before, during and after the actual psychedelic experience. "It's really tender and caring, and tuned to somebody's need. But that story doesn't get told. It just doesn't get translated into scientific journals as it's not part of their language," says Watts. "People see it as fluffy and soft, but that is the mechanism."

Olson acknowledges that psychoplastogens don't act as holistically as psychedelics, but argues that it is "not an either/or thing". Different drugs will be needed for different people, he says, balancing the effectiveness, safety and cost in each case. "For some patients, psychedelic-assisted therapy will be very important. The question is, do all patients need it?"

It is hard to see how psychedelic therapy can fit with the industrial medical narrative, where patients are passive recipients of a treatment and contact time is limited. To find a home for psychedelic therapy in our cash-strapped public healthcare systems, some say the levels of support that were offered in clinical trials will have to be cut back. "The cost is really substantial and it just becomes untenable," says Griffiths. "So how far can you back that down? I don't know, but I am concerned what will happen as this rolls out."

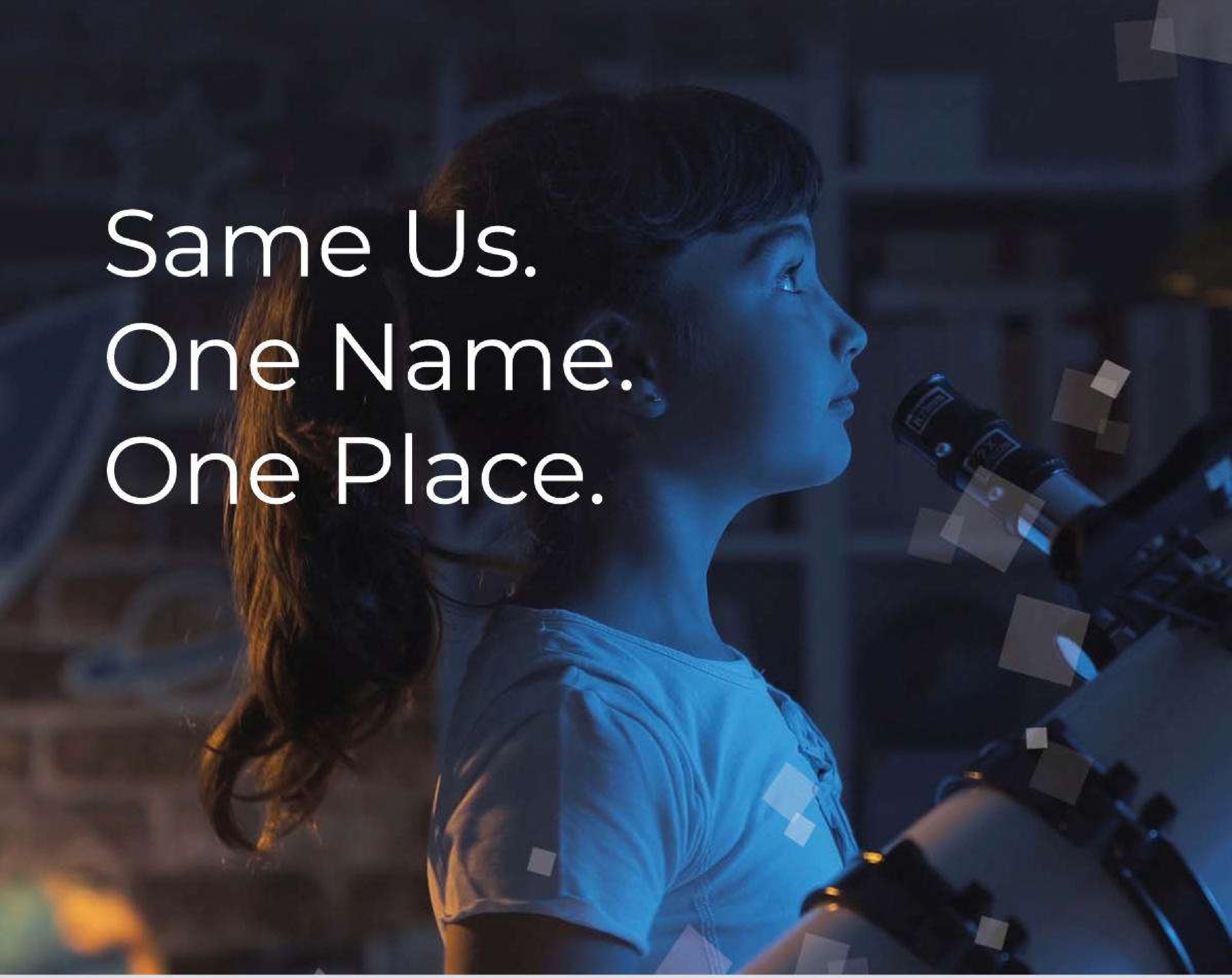
Carhart-Harris fears that this cost-cutting approach will go too far. "What you're left with is something which is no longer safe and effective enough," he says, which would not only harm those being treated, but also create a backlash for the practice as a whole. As part of his efforts to make sure that doesn't happen, Carhart-Harris opened a lab called Neuroscape last year where he and his colleagues are testing how to best guide a patient's psychedelic experience (see "The perfect trip", opposite page). There, he also hopes to identify which subjective components of psychedelic therapy are most beneficial or essential for safety, and so cannot be stripped away.

Meanwhile, Watts says we should rethink the relationship between our healthcare systems and society. Last month, she launched a therapy programme called ACER Integration, which is rooted in communities rather than the traditional patient-doctor dynamic alone. While therapists would still be essential for the actual psychedelic sessions, the guidance people need afterwards could be provided by grassroots networks. In this model, those receiving treatment become guides through their own experiences, and healing is as much about making connections with other people as it is about a self-transcendent trip.

Watts hopes to realise what some see as idealistic levels of patient support – and without the price tag. "Working together in a collaborative way to provide a safety net and support network probably sounds very dreamy, but it could work in terms of the real-world translation for the future of psychedelic medicine," says Carhart-Harris.

Relationships are important in any kind of therapy, adds Watts. Indeed, it is telling that one of the best predictors of outcomes in psychedelic therapy is a person's rapport with their therapist. "Psychedelics are really good at helping us feel a sense of community with other people," she says. "And it's something that we're really missing in our daily lives." ▮

Thomas Lewton is a science writer based in London, UK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Citizen science

Take part in the teabag trials

Are your teabags really biodegradable? If you compost your waste you can help researchers find out for sure, says **Layal Liverpool**

Layal Liverpool is a science journalist based in Berlin. She believes everyone can be a scientist, including you. @layallivs

What you need

Somewhere to compost e.g. a compost bin, trench or similar
A selection of compostable or biodegradable items
A net bag and clip
A plastic bottle cap and permanent marker pen

Citizen science appears every four weeks

Next week

Science of cooking

HOW biodegradable is your teabag? Are plastics labelled as biodegradable really what they claim to be? You can have a go at answering these questions and more by conducting your own home composting experiment.

If you live in the UK, you can submit your findings via the Big Compost Experiment citizen science project and contribute directly to waste innovation research. Start by choosing some items labelled as biodegradable or compostable. You might find inspiration from the project's ongoing Teabag Trials, which encourage volunteers to test out the supposedly environmentally friendly teabags that are now on offer from various brands.

Before putting your items into your composter, pop them in a plastic net bag, along with a plastic bottle cap labelled with a permanent marker – this will help identify your experiment later.

If you are an experienced composter, just carry on as you normally would. If you are new to the activity, there is guidance on the Big Compost Experiment website to help get you started. The process, which usually lasts weeks or months, harnesses animals and microorganisms to break down organic matter, allowing recycling of the many nutrients found within.

ALISTAIR BERG/GETTY IMAGES

Once you are ready to use your compost, you can take a photo and submit it to the Big Compost Experiment online, where you will also answer a few questions about the process you carried out. Your observations will help researchers, such as Danielle Purkiss at University College London, to better understand how so-called biodegradable or compostable materials actually behave.

Observations submitted since the project launched in November 2019 indicate that many of these materials don't break down as quickly during home composting as might be expected. "We can see that there is a significant range of things that are not working or are not actually… breaking down as the manufacturers would hope them to," said Purkiss, during a webinar on 25 April.

Results from volunteers have already shown that 66 per cent of biodegradable or compostable items placed in home composters were still intact, or had only partially degraded, by the time the compost was harvested.

Participants so far have used a wide range of composter types, plus different methods and time frames. "This is all very personal," said Purkiss. The diversity is what makes the home composting environment so challenging to design materials for, she said.

Purkiss hopes that the findings from the project will increase understanding of composting's environmental impact, and inform improvements to waste management in the UK. You can get involved by visiting bigcompostexperiment.org.uk. ▮

These articles are posted each week at newscientist.com/maker

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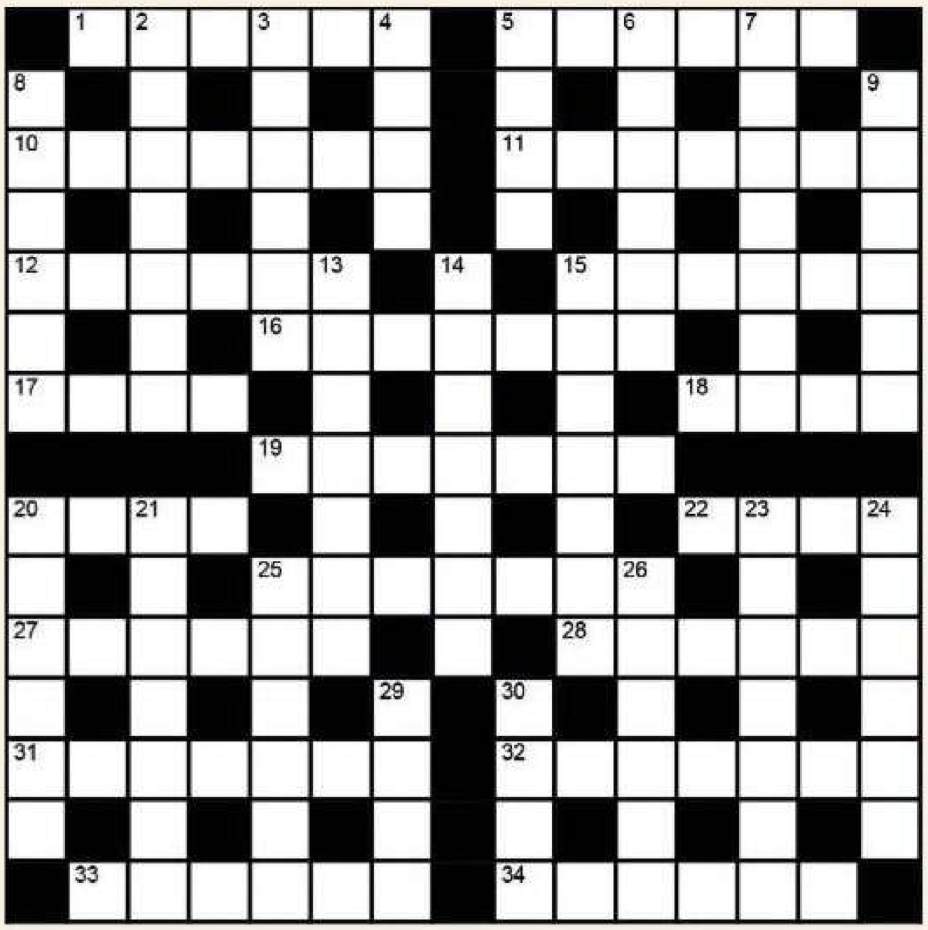
Quick crossword #109 *Set by Richard Smyth*



Scribble zone

Answers and the next cryptic crossword next week

ACROSS

1 Rat genus (6)
5 Systematise (6)
10 Brown coal (7)
11 3 × 5 (7)
12 Co (6)
15 1985 sci-fi film by Terry Gilliam (6)
16 *Cogito* ___, Cartesian axiom (4,3)
17 Pb (4)
18 Fe (4)
19 Synthetic textile (7)
20 Predatory freshwater fish (4)
22 Irritate; tickle (4)
25 Reliant on oxygen (7)
27 Spittle (6)
28 Lacking pigmentation (6)
31 Spacecraft (7)
32 Reptile, bird or mammal (7)
33 Of reproduced sound, multi-directional (6)
34 Organic remnant preserved in stone (6)

DOWN

2 Mathematical symbolism (7)
3 Threefold (6)
4 Stalk (4)
5 Rotator ___, muscle group in the shoulder (4)
6 Make misshapen (6)
7 Low-temperature storage unit (7)
8 Aliphatic diol (6)
9 Polysaccharide derived from chicory (6)
13 Windpipe (7)
14 Plane figure (7)
15 Eating disorder (7)
20 Engine component contained by a cylinder (6)
21 kb (7)
23 Mineral also known as rottenstone (7)
24 Vacuum cleaner brand (6)
25 2009 sci-fi blockbuster (6)
26 Genetically identical organisms (6)
29 Global oceanographic programme (4)
30 ½ (4)

Our crosswords are now solvable online
newscientist.com/crosswords

Quick quiz #154

1 Chiropterophily is the pollination of plants by which animals?

2 In what year was the US space station Skylab launched?

3 Name the first human virus to be discovered.

4 A sphygmomanometer is used to measure what?

5 In which US state would you find the largest flat-topped mountain, or mesa, in the world?

Answers on page 55

Puzzle

set by Holly Biming

#170 Presents, but not correct

"Have you written your thank-you letters, Kayleigh?"

"Not yet mum, just doing it now. Do I thank Amelia for the nail varnish, Beth for the book, Clara for the lip balm, Diaz for the pencils and Elinor for the sunglasses?"

"At least four of those are wrong."

"Ah, then was it Amelia for the book, Beth for the lip balm, Clara for the pencils, Diaz for the nail varnish and Elinor for the sunglasses?"

"That's better, but you've still made mistakes."

"How about Amelia for the lip balm, Beth for the sunglasses, Clara for the pencils, Diaz for the book and Elinor for the nail varnish?"

"Even better, but still not full marks. Clara didn't give you the pencils or the sunglasses."

"I give up."

Can you help?

Solution next week

Vowel-less

Why are there more consonants than vowels in alphabetic languages?

Bob Ladd
Edinburgh, UK

The answer partly depends on whether we are talking about the sounds or letters of vowels and consonants. By mentioning "alphabetic languages", the questioner is presumably asking why most versions of our alphabet have roughly 20 consonant letters but only five vowel letters.

The reason for that is simple: classical Latin (for which the Roman alphabet was designed) had about 20 consonant sounds and five vowel sounds. Writing systems tend to be conservative, so languages that use the Roman alphabet have mostly avoided making up new letters, but instead use combinations of letters ("th", "sh", "oi" etc.) or "diacritical" marks on existing letters ("é", "ü", "ç" etc.) to deal with new sounds.

> **"Try saying the alphabet and you'll see just how many tricks we use to form the sounds with our teeth, tongue and lips"**

Most versions of English have 12 to 15 distinct vowel sounds (and usually 24 consonant sounds), so getting by with only five vowel letters is part of the problem that many people experience with English spelling.

It is likely that most languages, alphabetic or not, have more consonant sounds than vowel ones. The World Atlas of Language Structures treats 19 to 25 as an average number of consonant sounds, but five or six for vowel sounds. One reason is that speech sounds have to be readily distinguishable by human listeners. There are a lot more ways to produce distinguishable consonants than vowels.

Is breaststroke a more efficient way to swim than front crawl?

CYLONPHOTO/GETTY IMAGES

This week's new questions

Different strokes **I am a casual swimmer who does a steady breaststroke in the pool. I am often overtaken by people doing front crawl, but who is actually swimming the more efficient stroke?** ***Cormac Byrne**, London, UK*

Pointing up **At what height do navigation compasses stop working?** ***Perry Bebbington**, Kimberley, Nottinghamshire, UK*

Francis Blake
London, UK

Vowels are formed by shaping the mouth space, largely without the use of the teeth, tongue or lips, and there are only so many distinct shapes one can make without the sounds becoming too similar, and thus causing confusion.

Conversely, consonants can be formed in any number of ways. Try saying the alphabet – minus the vowels – and you will see just how many "tricks" we use in forming the sounds.

Vowels are the main carriers of accent – and of confusion between speakers of the same language who have grown up in different places. I remember trying to tell some friends in Toronto that the picture they were looking at was of All Souls Church, next to Broadcasting House in London. In the end I had to write it down, as they simply couldn't understand my London vowels!

Alisoun Gardner-Medwin
Heddon-on-the-Wall, Northumberland, UK

The answer lies in the shape of the human mouth and how we form sounds. Vowels are created when our lips are open and there are no restrictions to prevent the sound getting out. To form a consonant, we restrict the opening in one of several ways, and there are groups of consonants that share a particular form of restriction.

These groups were suggested by Jacob Grimm, one of the Brothers Grimm who collected folk tales in the early 19th century. He formulated what we call Grimm's law, to explain why the consonants in a group are related.

Dental consonants are formed when we put the tip of the tongue behind the teeth. Letters in this group are a hard "t", as in tea, a soft "th", as in theatre, and a harder "th", as in that. Other groups are labials, made using the lips, such as "p", "b", "v", "w" and "f". Gutterals are formed with open lips, and the restriction is in the back of the throat, to form "g", "k" and "x".

Herman D'Hondt
Mascot, New South Wales, Australia

What is often overlooked is that many languages have far more vowel sounds than there are letters for. We compensate for this in two ways. First, each letter can be pronounced in a variety of different ways. Think of the "e" in the, them, there and these. Or the "a" in rat, rate, war, ware and lark. This variety is far less common with consonants.

The second method used to expand the number of vowels is to combine them, either with other vowels – think of "oo", "ou" and "eu" – or with diacritical marks. German uses the umlaut diacritic to change the sound of several vowels, for instance "ä", "ö" and "ü". Only rarely are diacritics used to alter a consonant. One example is the French cedilla, as in *leçon*.

Jane Henderson
London, UK

It isn't always true that there are more consonants than vowels in written alphabets. My *Complete Korean: Teach Yourself* book tells me there are 21 vowels and 14 basic consonants in Hangul, the Korean alphabet (sometimes five of these double up, but arguably those doublings aren't separate consonants). Even allowing for the three consonants that are pronounced differently depending on their surrounding letters, the vowels win.

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Tom Gauld

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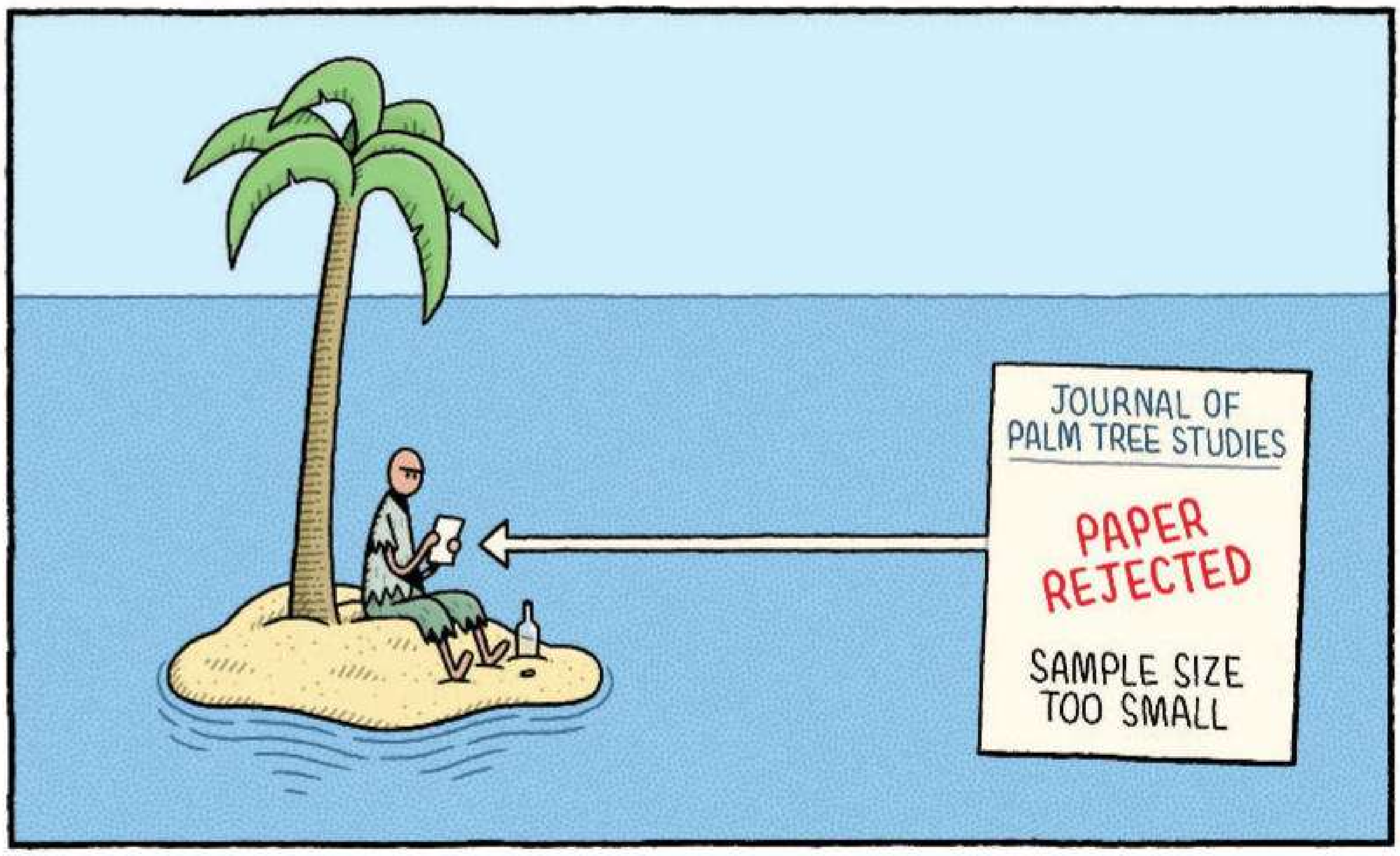


Wagging question

Why do wagtails wag their tails? They would be well camouflaged, if it weren't for their constantly moving tails.

Chris Daniel
Glan Conwy, Conwy, UK

On a walk the other day, I spent several minutes watching a yellow wagtail darting, its tail bobbing continuously. I wondered about the purpose of this behaviour, then I came home and opened the edition of *New Scientist* with this very question.

Many bird species move their tails, either bobbing them up and down like the European wagtails or waving them from side to side like the willie wagtail in Australia. Many other birds also exhibit tail-flashing or flicking behaviour.

The wagtail's eponymous movement is thought to be an evolutionary adaptation to enhance feeding by flushing out hidden insects that it feeds on. A study has shown that tail-flicking is a positive predictor of foraging performance in a juvenile species of warbler. It may also be used as a sign of submission to other birds of the same species and as a marker of alertness to potential predators to discourage pursuit, in a similar way to the tail-flagging behaviour of deer.

My limited observation of wagtails is that the rhythmic movement is almost continuous, whether or not the bird is feeding, so more than one of these explanations for it may be true. The movement also appears to be involuntary, superimposed on other activities such as walking and preening.

> **"Being unnoticed is the best way to avoid being eaten, but this also entails not venturing out for food or attracting mates"**

Garry Trethewey
Cherryville, South Australia

All animals must negotiate a lot of conflicting needs. Being unnoticed is the best way to avoid being eaten. But to be unnoticed also entails not venturing out for food, not seeking or attracting mates and not proclaiming ownership of territory.

Many animals are loud, colourful and display prominently. The risk is offset by the benefits this entails, and their ability to escape danger in other ways.

Mike Follows
Sutton Coldfield, West Midlands, UK

The most likely explanation is that they wag their tails to give the impression that they are alert, to encourage predators to look elsewhere for an easier meal.

It is unlikely that the wagging is meant to attract a mate, as even juvenile birds do it, which would be a waste of energy. Also, the frequency or amplitude of wagging doesn't depend on the proximity of potential mates.

There is speculation that the wagging tail flushes out insects, but this seems unlikely as surely other species would also have evolved this trait. ▮

Answers

Quick quiz #154
Answers

1 Bats
2 1973
3 Yellow fever virus
4 Blood pressure
5 Colorado. The Grand Mesa covers around 1300 square kilometres

Cryptic Crossword #84 *Answers*

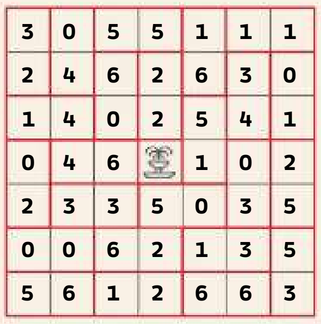
ACROSS 6 Bleach, **7** Unrest, **9** Swam, **10** Mediate, **11** Spa day, **13** Gamete, **15** Pom-pom, **17** Gimbal, **18** Obverse, **20** Node, **22** Asking, **23** Scurry

DOWN 1 Glow, **2** Dammed up, **3** Whimsy, **4** Sun dog, **5** Area, **8** Spectra, **12** Photons, **14** Momentum, **16** Mirage, **17** Grease, **19** Void, **21** Dark

#169 A Domino Piazza
Solution

A full set of dominoes has eight of each number. In the piazza, there are eight 0s and 1s, and seven 2s, 3s, 5s and 6s, so we can be sure that the 0-0, 1-1, 2-2, 3-3, 5-5 and 6-6 dominoes all appear.

6-6 and 0-0 can be identified immediately, which forces 5-6 (bottom left) and 5-3 (bottom right), so barriers can now be drawn between any other 5-3 and 5-6 pairs, and 5-5 must be in the top row. From this the whole pattern can be found. The missing dominoes are 4-4, 4-2, 5-4 and 6-3.



3	0	5	5	1	1	1
2	4	6	2	6	3	0
1	4	0	2	5	4	1
0	4	6		1	0	2
2	3	3	5	0	3	5
0	0	6	2	1	3	5
5	6	1	2	6	6	3

Rogue editors

If you ever feel in need of some light entertainment alongside insights into the decline of research integrity and the scientific method, try perusing a website called Retraction Watch.

As *New Scientist* has previously described, some fear that papers in peer-reviewed journals – once seen as the most authoritative source of information – are increasingly untrustworthy, because scientists' careers these days hinge on their publication tally, incentivising quantity over quality. Retraction Watch documents official retractions of papers – either due to honest errors or outright fraud – often accompanied by wry commentary and the occasional eye-roll.

Feedback thought we already knew most of the ingenious ways that fraudulent papers could get published, but Retraction Watch's latest find is a new one on us, involving the phenomenon of "rogue editors". This sees fraudsters impersonating real scientists when they write to a journal's editor suggesting a special issue on a hot topic that they kindly offer to guest-edit. You can guess what happens next: they accept papers written by their confederates or perhaps even themselves, which could, for instance, be full of gibberish copied and pasted from the internet. These papers artificially inflate someone's list of publications.

Victims include the *Arabian Journal of Geosciences*, which suffered the embarrassment of somehow publishing a special issue that included discussions of aerobics, running wear and Latin dancing, and the *Journal of Nanoparticle Research*, which said after an attack that the main problem is the "exponential growth of scientific publications... which leads to the publication of a huge background noise of useless and low-level articles".

At last, official confirmation from a journal of something Feedback has long suspected: most scientific papers are useless.

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Spaced out

If you think journal editors have a tough life, spare a thought for those multimillionaires who took part in NASA's first tourist trip to the International Space Station. Possibly stung by criticisms such as the fact that each person's trip will release hundreds of times more carbon than a typical holiday on the Costa del Sol, NASA had been vocal about plans for the tourists to do some useful work on board, such as experiments on human cells and optical lenses.

Awkwardly, at a press conference held when the three men landed back on Earth, one of the main topics was how they had been worked too hard. Not what you might expect from a holiday that cost $55 million a head. "With the value of hindsight, we were way too aggressive on our schedule," said Larry Connor, a real estate billionaire from Ohio. One experiment that had been slated to take 2.5 hours ended up taking twice that time, he said.

Another sticking point was how much the real astronauts' schedule was disrupted by having to hand-hold the tourists. In a review afterwards, safety expert Susan Helms admitted that the tourists' arrival had a "larger-than-expected impact on the daily workload" of the crew, something they would try to reduce in future trips, according to SpaceNews.

The trip was originally scheduled to last eight days, but was extended to 15 because of bad weather at the landing site – something the tourists said they were thrilled about. We didn't hear how the crew felt. Feedback's suggestion: next time, NASA should forget the experiments and let the tourists bring along their butlers.

Define 'define'

An unusual outbreak of cross-disciplinary collaboration began on Twitter recently, when @halvorz made the provocative claim that every academic discipline has at its core a "word of power" that everyone has given up trying to define. In genetics, that word is "gene", in chemistry it is "molecule", while in medicine it is "health", according to some who chimed in.

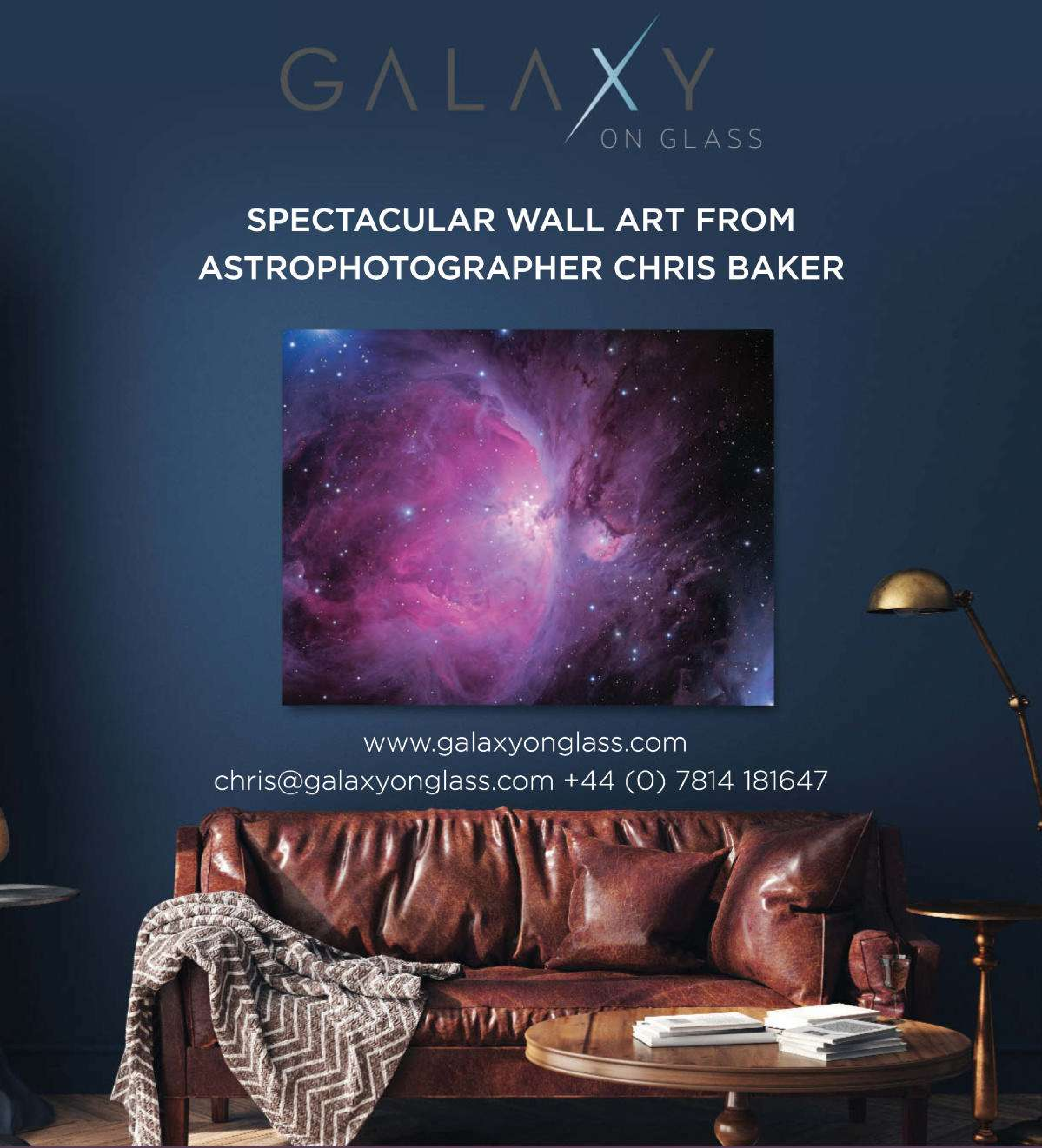
In Feedback's experience, for many of these words, the definitions haven't so much been given up on, as become the subject of rancorous debates that have destroyed relationships, careers or even the odd world, metaphorically speaking. If astronomers could have agreed from the start on the definition of "planet", poor old Pluto wouldn't have lost its status so humiliatingly.

Fortunately, there was little rancour visible in this particular debate, although the linguists couldn't agree on their impossible-to-define word. One suggested "word", while another insisted it was, in fact, every word. The big surprise was from ornithology, where someone thought it might be "warbler". Who knew?

New word needed

Speaking of words, Feedback's proudest achievement is giving the world the term "nominative determinism". Now, reader Philippa Sandall – who isn't a shoe-maker – thinks the column and its readers should devise a timely new word to describe the phenomenon of people who expound on controversies despite knowing no more about them than the average person – possibly even less. Feedback is usually stuck next to them at parties.

We need a word that means the exact opposite of expert, but "anti-expert" is too boring. Sandall proffers "nixpert", but is sure that *New Scientist* readers could do better. Suggestions please. ▮



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